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KUSKOKWIM RIVER SONAR PROJECT
ABUNDANCE ESTIMATES OF SALMON SPECIES, 1993

by

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ABSTRACT

The Kuskokwim River sonar project provided estimates of salmon species passage from 3 June through 20 August. Project upgrades in 1993 included: 1) changing the operating frequency from 420 kHz to 120 kHz to avoid signal attenuation experienced in previous years, and 2) hydroacoustic sampling on the left bank using radiotelemetry equipment. Fish passage in the unensonified mid-river zone was estimated by assuming uniform distribution throughout the river's cross-section. Severe hydroacoustic noise was encountered on the right bank, and was alleviated through sonar system and signal processing software parameter settings. Total season passage estimates were 92,618 chinook, 282,461 sockeye, 422,862 chum and 317,025 coho salmon. Whitefish seasonal passage was estimated at 384,098. Test fishing CPUE at the sonar site corroborated sonar passage estimates, with the exception of coho salmon. Coho salmon passage may have been overestimated, due to cisco being detected by sonar but not being caught in the test fishery. Dual-beam data collected was invalid.

KEYWORDS: Salmon, hydroacoustic, Kuskokwim River, escapement.

INTRODUCTION

Kuskokwim River salmon stocks are harvested for both commercial and subsistence use. Commercial fishing harvests from 1988-1992 averaged approximately 1,325,000 combined chinook, sockeye, coho, and chum salmon. Revenues from in-river harvests during the same period averaged nearly $5.0 million. In addition, an estimated average of approximately 240,000 salmon were taken annually for subsistence purposes. Commercial fishing occurs through 375 km (233 mi) of the river, with the most intensive commercial fishery located in the area within 220 km (137 mi) of the river's mouth. Subsistence fishing occurs through approximately 1,184 km (736 mi) of the river's total 1,498 km (931 mi) length, and primarily targets chinook and chum salmon. Management of the fishery resource requires timely estimates of run strength and escapement. Visual estimation of migrating salmon abundance is precluded by turbid water, and an extensively braided, relatively deep river channel. Historically, this commercial salmon fishery has been managed based on catch per unit effort (CPUE) data from test gillnets and the commercial fishery, and on escapement assessment from upriver spawning tributaries as they become available. CPUE has limited value as an abundance index however, because it is confounded by variable catchability of fish. The major limitation to the use of spawning tributary data as a management tool is that by the time reliable assessments of escapement can be made, a large portion of the stocks have passed through the primary commercial and subsistence fishing areas in the river mainstem.

The purpose of the Kuskokwim River sonar project is to provide daily passage estimates of chinook, sockeye, chum and coho salmon at Bethel. The project began with a three year feasibility phase (1988-1990), and has continued to develop since that time. In 1991, the Bethel test fishery project was restructured to provide data for estimation of species proportions . This was used together with sonar project passage estimates to provide estimates of daily passage for each species. By the end of the 1991 season, it was clear that two problems required resolution to ensure project success. First, an economically feasible method of sampling on the left bank (facing downstream) was needed. Second, the attenuation of 420 kHz sound caused reduced sampling volume as well as bringing into question the validity of dual-beam data (Mesiar et al., 1994).

In 1992, project operation funds were reprogrammed to the purchase and testing of new equipment to address these problems. Custom designed radiotelemetry equipment was developed by the University of Alaska Fairbanks (UAF) Geophysical Institute to transmit data remotely from the left bank to the right bank control center. Transducers designed to operate at a resonant frequency of 120 kHz were also tested at this time to avoid signal attenuation experienced with the 420 kHz frequency previously used on the project. Testing of both of these enhancements was successful. Target strength analysis from dual-beam data collected by the Kuskokwim River sonar project in 1992 revealed no modal separation of salmon and non-salmon targets, unlike length frequency distributions of the salmon and non-salmon species. This decreased optimism that target strength analysis might provide a means of acoustically separating salmon from whitefish and cisco. The equipment tested in 1992 (radiotelemetry, 120 kHz sound) became a part of routine project operation in 1993. To date, daily estimates of passage have not been used in managing salmon stocks on the Kuskokwim River. Managers agree that passage estimates from the project should be used for in-season management decisions in 1994.

The site used for hydroacoustic sampling since project inception is located at river km 130 (mi 79), approximately 5 km (3 mi) upstream from Bethel (Figure 1). This site was selected based on physical characteristics favorable to hydroacoustic sampling. The bottom at this site has a uniform gradient, with a maximum depth of approximately 12 m. The river has a single channel, although three relatively small sloughs bypass the site. The river is approximately 475 m wide during high tide at the sonar site. A mud bar on the left bank extends approximately 125 m into the river channel, and water behind the bar is very shallow. The left bank transducer is deployed just on the offshore side of the mud bar, making the distance between transducers on each side of the river channel 350 m. Water flow is affected by tidal fluctuations and flow direction is occasionally reversed on particularly high tides. The only known salmon spawning stream that is downstream from the site is the Eek River, located at approximately river km 19 (mi 12).

METHODS

Hydroacoustic Sampling

Equipment and Procedures

Equipment. The sonar system on the right bank consisted of a [2]Biosonics model 102 echosounder, a Biosonics model 151 Multiplexer, two Biosonics model 111 thermal chart recorders, and a Biosonics model 181 Echo Signal Processor (ESP) card installed in a Compaq Deskpro 386 microcomputer. Support electronics on the right bank included a Nicolet model 310 digital storage oscilloscope, a Compaq 8088 microcomputer, a Remote Ocean Systems (ROS) model PTC-1 remote pan and tilt controller with digital position feedback, and UAF-developed radio telemetry equipment used to remotely operate the left bank sonar system. The left bank sonar system was limited to a Biosonics model 102 echosounder and the radiotelemetry equipment. Radiotelemetry equipment functioned to telemeter data from the left bank to the right bank control system, remotely start and stop the left bank generator, and act as a pan and tilt control unit for the left bank transducer. Sonar systems and support electronics on each bank were powered by Honda EM-3500 generators. International Transducer Corporation (ITC) model 5398 elliptical transducers were used that

[2]Use of vendor names does not constitute endorsement.

were configurable for split or dual-beam operation, as well as several different beam angles. Transducers on each bank were configured for dual-beam mode. The right-bank transducer was configured for a nominal beam angle of 2.0° x 4.7° narrow beam, 4.1° x 9.5° wide beam. The left-bank transducer was configured for a nominal beam angle of 4.0° x 9.1° narrow beam, 13.1° x 21.4° wide beam. ROS PT-25 pan and tilt assemblies allowed transducers to be remotely rotated through pan and tilt axes. Transducers were attached to the pan and tilt assemblies which were mounted on steel tripods for deployment. The electronic equipment on each bank was housed in a 2.4 m x 3.0 m (8 ft x 10 ft) wall tent on a wood platform.

Sampling Design. Single-beam sampling was continuous on both banks, except for routine maintenance, equipment malfunction, and periods when wind or heavy rain caused severe acoustic noise. Sampling on the right bank extended to a range of 180 m. Maximum sampling range on the left bank was 75 m. In single-beam operation, chart recordings constituted the only record of detected echoes and fish passage. Dual-beam samples were collected in 2-h periods, alternating between right and left banks (Table 1). Dual-beam sampling was occasionally discontinued when background noise levels were too high to permit collection of valid target strength data. High background noise was most often caused by high wind or heavy rain events.

A single fishery technician operated and monitored equipment at the control center. Crew members rotated through shifts of 0800-1600, 1600-2400, and 0000-0800 hours. During these shifts, crew members tallied fish traces from charts and recorded fish passage counts summarized in 15 minute intervals and 20 m range strata. Summarized data were subsequently transferred from hard copy data forms to electronic spreadsheets for estimating daily total passage.

To determine the proportion of fish passage in the river that was beyond the range of side-looking sonar beams, transects across the full width of the river were conducted with a Lowrance X-15 graphing fathometer. Transects began at a point approximately 20 m downstream from the right-bank transducer and ended at a point approximately 30 m downstream from the left-bank transducer. Boat speed and chart recorder paper speed were held constant so that chart recordings would have a consistent distance scale. Chart recorder gain was varied to eliminate as much electronic noise as possible. Six replicate transects were completed three times each day (approximately 0500, 1100, and 1700 hours).

System Parameters. Echosounder settings and ESP parameters were modified on the right bank system on 11 June to reduce high background noise levels experienced at that time (Table 2). Left bank settings were similarly modified on 24 June. In brief, the modifications held Time-Varied-Gain (TVG) amplification of target signals constant after 40 m. Normally, TVG increases through the entire sampling range by $40(\log_{10} r)$, where r = range (m). The altered TVG amplification solved the problem of system and environmental noise amplified through the TVG function beyond 40 m, where noise became severe. In order to ensure dual-beam detection of fish in the ranges beyond 40 m on the right bank, transmit power and receiver gain were increased, and voltage threshold in the ESP software was set incrementally lower with range, such that a -41.5 decibel-volt (dBv) target would be detected on the maximum response axis (MRA) through the entire sampling range (Table 3). Because the acceptable beam pattern factor (BPF) set was 0 to -6 dBv (i.e. from the MRA out to an angular position in the beam at which the signal strength had decreased by 6 dBv), the smallest size fish that was sampled in an unbiased fashion was -35.5 dBv. Because the chart recorder voltage threshold could not be varied with range, the smallest fish that could be detected and displayed varied with range. The smallest fish that could be detected on the MRA at 50 m had a target strength of -60.8 dBv, while at 180 m the smallest fish detectable on the MRA had a target strength of -38.6 dBv (Table 4). At the beam's half-power point (-6 dBv), the smallest fish detectable at these ranges had target strengths of -54.8 dBv and -32.6 dBv, respectively. Left bank threshold was -52.4 dBv at 40 m and -41.5 dBv at 75 m on the MRA. At the half power point for these ranges, fish no smaller than -46.4 dBv and -35.5 dBv could be detected and displayed on the left bank chart recorder.

System Calibration. Sonar systems used on both banks were calibrated in late May 1993 by Precision Acoustic Systems, Seattle WA. Additionally, dual-beam target strength data from a standard target (38.1 mm diameter tungsten carbide sphere) were collected in the field using the right bank system on 30 June. An equatorial net-bag of monofilament line supported the sphere. The sphere and net-bag were suspended by a length of monofilament line attached to the end of a pole deployed from the side of an anchored boat. Once the sphere was detected in the sonar beam, the transducer was aimed from the control center until the sphere was approximately on the MRA. Standard target data were collected on the left bank system on 29 June and 25 July by the same method as was used on the right bank. Right bank standard target data were analyzed in-season. Left bank standard target data were analyzed post-season.

Analytical Methods

Estimates of Daily Total Fish Passage. Because a high concentration of small traces seen in the right bank 0-40 m zone could not be identified as debris or adult or juvenile fish, tallies from this zone were not used in estimating daily fish passage. Because of concerns about the validity of transect data, a decision was made in-season to not use these data to estimate passage in the unensonified zone (the mid-river area not sampled by the two side-looking systems). These concerns included: 1) unknown degree of boat avoidance near the surface; 2) difficulty separating fish from debris on fathometer chart recordings; and 3) low sample coverage in both time and space. Transects were performed throughout the season according to the operational plan, in the event that they would be useful for post-season data analysis. Passage in the unensonified zone and in the 0-40 m zone of the right bank was estimated using mean passage rates in ensonified zones. Daily passage estimates were generated through a Quattro Pro 1.0 worksheet.

Daily total fish passage within the ensonified zone ($\hat{Y}_{ed}$) was estimated as

$$\hat{Y}_{ed} = \frac{\sum_{b}\sum_{c}\sum_{q=1}^{n_q} y_{dbcq}}{(n_q)/96} \tag{1}$$

where: y_{dbcq} = estimated passage of fish on date *d*, on bank *b*, in range sector *c*, in 15-minute subsample *q*, and n_q = number of subsamples in day's total sampling.

Daily fish passage in the river's total cross-section ($\hat{Y}_d$)was then estimated by the product of passage in the ensonified zone and the ratio of total range (r_t) to range ensonified (r_e), i.e.,

$$\hat{Y}_d = \hat{Y}_{ed}\left(\frac{r_t}{r_e}\right) \tag{2}$$

Since tallies from the first 40 m of the right bank were not used in estimating total fish passage, this portion of the river's width was treated as if unensonified, and

$$\hat{Y}_d = \hat{Y}_{ed}\left(\frac{350}{(180-40)+75}\right)$$

$$= \hat{Y}_{ed}\ (1.628).$$

Dual-beam Data. Dual-beam data were processed post-season with ADF&G-developed software (CONVERT 2.1, PIPE 1.5, DUAL-BEAM DATA PROCESSOR [DBDP] 1.0), and software developed by Biosonics, Inc. (DBREAD 1.0). CONVERT 2.1 was used to convert data collected by ESP 1.0 and ESP 2.1 to a format readable by DBDP 1.0 and DBREAD 1.0. PIPE 1.5 was used to generate data input files that allowed DBDP to run in batch mode. DBDP 1.0 is the main data processing software. It uses as input dual-beam data already roughly filtered for amplitude, pulse width and frequency in collection by ESP and outputs a '*.eko' file listing all echoes that were grouped into fish and several parameters for each echo. A '*.fsh' file is also output that consists of summarized data such as mean target strength and range of each fish. Each fish in the '*.fsh' file consists of a group of echoes that were linked together as one fish in the '*.eko' file. DBREAD 1.0 allows collected 'raw' data to be viewed directly. It does not calculate values such as target strength or BPF (distance from the MRA, expressed in decibels), or group echo collections into fish as does DBDP 1.0.

Output from DBREAD 1.0 was plotted in the form of cumulative proportion of echoes with incrementing voltage intervals. This was used to compare the proportion of saturated right bank (wide beam) echoes that were within the 0-40 m zone with the proportion of saturated echoes from the zone beyond 40 m before and after system parameter changes made on 11 July. Left bank data output by DBDP 1.0 was used to prepare frequency histograms of BPF.

Transect Data. Transect chart recordings were digitized using a Summagraphics SummaSketch II Professional digitizing tablet with in-house developed software (KDIG 1.0). Fish were located on an x:y coordinate grid where x = distance, y = depth. Maximum depth was defined as a constant 9.1 m (30 ft). Maximum distance was defined as 350 m (383 yds). On the x axis, zero m corresponded to the right bank, 350 m to the left bank. Because the fathometer's sonar beam expanded in diameter with depth (range), probability of detection was also variable with range. To correct fish distribution to reflect equal probability of detection with depth, individual fish detected were expanded by their relative probability of detection,

$$C = \frac{r_m}{r_t} , \tag{3}$$

where: r_m = maximum depth, and r_t =depth of target.

Digitized fish traces from fathometer transects were plotted to show cumulative spatial distribution of fish in the river's cross-section.

Species Apportionment

Equipment and Procedures

Set-gillnet program. Set-gillnets were used in the near-shore zone (0-40 m) to estimate species composition for apportionment of sonar counts in this zone. All nets were 45.7 m (150 ft) in length. Four mesh sizes were fished: 7.0 cm (2.75 in), 10.2 cm (4.0 in), 12.7 cm (5.0 in), and 15.1 cm (5.5 in). Nets were fished twice each day at or just before high tide. The 7.0 cm and 12.7 cm mesh nets were paired, as were the 10.2 cm and 15.1 cm mesh nets. These net pairs were alternated between banks on a daily basis. On the right bank, nets were fished 15 and 25 m downstream from the transducer location. Nets on the left bank were fished at stations 75 and 55 m upstream from the transducer. In each case, the larger mesh net of a pair was fished farthest downstream. Nets were anchored on both ends and oriented perpendicular to shore. Fishing time was targeted at approximately 20 minutes. Times of net start-out, full-out, start-in and full-in were recorded for calculation of effort. Species and length of all fish captured were recorded. Length for salmon species was recorded as mid-eye to fork-of-tail, non-salmon species as snout to tail. Data were stored in an RBASE 2.0 database file.

Drift-gillnet program. The methods and location used in the 1993 Bethel test fishery are outlined by Molyneaux (1993). To apportion sonar passage estimates by species, nets of 16.5 cm (6.5 in) and 10.2 cm (4.0 in) stretched mesh were added to the 20.3 cm (8.0 in) and 13.6 cm (5.4 in) nets routinely used in the Bethel test fishery. Gillnets were drifted at one of three stations corresponding approximately to: 1) left bank , 2) mid-channel, and 3) right bank. Nets were fished on each tide according to a rotating schedule of six unique permutations of mesh sizes to be fished among the three stations (Table 5). Fishing periods began approximately one h after high tide and continued until all scheduled drifts had been completed. After 5 July the daily chinook salmon CPUE in the Bethel test fishery had declined to 0.7% of the total. Use of 20.3-cm mesh gillnets was discontinued at that time and the fishing schedule modified so that the 13.6-cm mesh gillnet was fished once at each station, on every tide (Table 6). Times of net start-out, full-out, start-in and full-in were recorded to the nearest minute for effort calculation. Date, tide, station, species, and length of fish caught were recorded for each drift. All cisco and whitefish species caught in drift gillnets were categorized as 'whitefish'. Fish length was measured as previously detailed for set gillnet catches. Fish caught in set and drift gillnets were sold to a local processor or donated to organizations and individuals.

Analytical Methods

Estimates of Species Proportions. The procedures used for estimating species proportions were modified from those of Fleischman et al. (1992) for the lower Yukon River. Because of in-season time constraints in 1993, the set gillnet catch was not used to estimate species proportions in the 0-40 m zone. Drift gillnet test fishery data were pooled across stations 1-3 to estimate average species proportions for the entire river cross-section. To maximize sample sizes, test fishery data were further pooled into three-day report periods. Report periods were extended when necessary to ensure a sample size of at least 20 fish. A SAS program (BTF93.SAS - Appendix A) was used to estimate species proportions and daily fish passage by species. Species proportions were derived from relative test fishery CPUE, after first adjusting for gillnet size-selectivity.

In the program, fishing time t for drift j with mesh size m during test-fishing period f at station s in report period r was calculated as

$$t_{rsfmj} = SI - FO + \frac{FO-SO}{2} + \frac{FI-SI}{2}, \tag{4}$$

where SO = net start out, FO = net full out, SI = net start in, and FI = net full in.

To estimate the proportion of species i, catch c of species i and length class l during drift j of mesh m during test-fish period f at station s in report period r was first adjusted for net selectivity S of species i and length class l in mesh m. Adjusted catch a was calculated as

$$a_{ilrsfmj} = \frac{c_{ilrsfmj}}{S_{ilm}}. \tag{5}$$

If S_{ilm} was undefined because the fish was outside the range of lengths for which selectivity estimates were available, adjusted catch was set to zero. Length intervals of 40 mm were used for all species other than chinook salmon, for which 100 mm intervals were used. Net selectivity functions for chinook, chum, coho, sockeye, and pink salmon, as well as whitefish were generated from 6,182 fish captured in the 1991 and 1992 Bethel test fishery project (Steve Fleischman, Alaska Department of Fish & Game, personal communication). Net selectivity coefficients were estimated for chinook, sockeye, chum, and coho salmon, as well as whitefish (Figures 2 and 3). Two or three mesh sizes were used to estimate the abundance of each species (Table 7). For pink salmon, sheefish, and other species lacking selectivity estimates, the mean selectivity of all species with known selectivity (0.7) was used for fish regardless of length.

Total effort, in fathom hours of drift j with mesh size m during test-fishing period f at station s in report period r was calculated as

$$e_{rsfmj} = \frac{50 \cdot t_{rsfmj}}{60}, \tag{6}$$

since all nets were 50 fathoms long.

CPUE, across all drifts j with all mesh sizes m, for length class l of species i during test-fishing period f at station s in report period r was computed as the total adjusted catch divided by total effort,

$$CPUE_{ilrsf} = \frac{\sum_m \sum_j a_{ilrsfmj}}{\sum_m \sum_j e_{rsfmj}} . \qquad (7)$$

CPUE was then summed across all length categories for each species i, and the estimated proportion p of species i during test-fishing period f at station s in report period r was the ratio of CPUE for species i to the total CPUE for all species,

$$\hat{p}_{irsf} = \frac{\sum_l CPUE_{ilrsf}}{\sum_i \sum_l CPUE_{ilrsf}} . \qquad (8)$$

For report period r, the proportion of species i was estimated as

$$\hat{p}_{ir} = \frac{\sum_s \sum_f \sum_l CPUE_{ilrsf}}{\sum_s \sum_f \sum_i \sum_l CPUE_{ilrsf}} , \qquad (9)$$

which is the equivalent of the mean of all test-fishing period proportions weighted by the total CPUE for all species in each test-fishing period.

Fish Passage by Species. The passage of species i for report period r was estimated as

$$\hat{Y}_{ir} = \sum_d \hat{y}_d \cdot \hat{p}_{ir} , \qquad (10)$$

where the summation is over all days in the report period.

Finally, passage estimates were summed over all report periods to obtain a seasonal estimate for species *i*,

$$\hat{Y}_i = \sum_r \hat{Y}_{ir} \; . \qquad (11)$$

Missing Data. Because species proportions were estimated from pooled three-day periods, the effect of drift gillnet data that was occasionally missing on estimates of species proportions was small.

RESULTS

Hydroacoustic Sampling

Estimates of Daily Total Fish Passage

Hydroacoustic sampling on the right bank began on 3 June and continued through 20 August. On the left bank, sampling took place from 20 June through 20 August. Total passage estimated for all species combined in the 1993 season was 1,514,372 fish (Figure 4, Appendix B.1). The point of 50% total passage was reached on 12 July. Peak daily passage was 45,518 fish on 15 July (Appendix B.2). A total of 471,007 fish were estimated passing on the left bank, 567,923 on the right bank, and 475,442 in the unensonified zone.

Dual-beam sampling

Dual-beam data collected on both banks were found to be invalid for target strength analysis. Analysis of dual-beam data collected after 11 June on the right bank showed nearly all echoes within the 0-40 m zone to have saturated voltages. In contrast, data collected before 11 June showed nearly all echoes to have voltages between 0 and 2.0 V (Figures 5 and 6). Voltage saturation refers to a condition in which a signal's peak voltage is greater than the maximum voltage the echosounder is designed to measure. The Biosonics model 102 echosounder is designed to accommodate voltages of up to approximately 10.0 V (in the model 102 echosounder used on the right bank, saturation occurred at 9,991.8 mV). Analysis of dual-beam data on the left bank revealed that nearly all echoes had higher narrow beam than wide-beam voltages (Figure 7). This condition is referred to as over-axis, and results in a BPF greater than zero. Echoes with BPF greater than zero are considered invalid for use in target strength analysis.

Transects

Transect data unadjusted for probability of detection indicated that fish in the river cross-section were bottom and surface oriented (Figure 8). Range distribution of fish from transect data adjusted for variable detection probability with depth (Figure 9) was visibly different than range distribution obtained from side-looking sonar (Figure 10). In particular, the range distribution from down-looking sonar is nearly the inverse of the side-looking sonar distribution between 275 and 350 m.

Species Apportionment

Total passage estimates for salmon species were 92,618 chinook, 282,461 sockeye, 422,862 chum, and 317,025 coho (Appendix B.1). Chinook salmon passage in Appendix B is further divided into small chinook (< 640 mm) and large chinook (≥ 640 mm). Passage of salmon species (apportioned by drift gillnet test fishing) compared closely with CPUE for each species from the Bethel test fishery, with the exception of coho salmon (Figures 11-14). Chinook salmon sonar passage estimates also showed a brief pulse in late July that was not mirrored in the test fishery (Figure 11). Daily passage of whitefish began to increase in late June, peaked 13 July and had ended for all practical purposes by 31 July (Figure 15). This was generally corroborated by whitefish CPUE in set nets. Set net CPUE showed that substantial numbers of ciscos were still passing in the near-shore zones of the river in mid-August (Figure 16).

A total of 1,249 fish were caught in set gillnets deployed in the 0-40 m zone of the right and left bank. Salmon species of interest (chinook, sockeye, chum, and coho) made up 56.8% of all fish captured (Table 8, Appendix C). During the period 15 July - 18 August, cisco made up 43.8% and 34.3% of the set-net catch on right and left banks, respectively. This was the highest proportion contributed by any species during this period. After about 22 July, coho salmon and cisco were the dominant species in the set net catch (Figure 16).

DISCUSSION

Hydroacoustic Sampling

We believe that coho salmon passage was biased toward overestimation because ciscos were likely tallied as fish on chart recorders, but not represented in the test fishery catches. Coho salmon run timing coincides roughly with that of ciscos (Figure 16). Selectivity estimates used in 1993 for cisco in 10.2 cm gillnets did not extend to fish lengths less than 300 mm, thus ciscos less than 300 mm were not considered in the apportionment process. Size distributions of cisco from 7.0 cm and 10.2 cm set gillnets indicate ciscos less than 300 mm long represent roughly half of this distribution (Figure 17). We believe that thresholds in place on right and left bank chart recorders (Tables 4 and 5) allowed ciscos less than 300 mm to be detected. This is supported by findings of other freshwater hydroacoustic studies (Mulligan and Kieser 1986, Burczynski and Johnson 1986), unadjusted for frequency differences.

Dual-beam Sampling

The method used to reduce the effect of noise at ranges greater than 40 m on the right bank compromised the dual-beam data in the 0-40 m zone. Increasing the receiver sensitivity and transmit power sufficiently to detect -41.5 dBv targets at 180 m with only 40 m TVG signal amplification caused most echoes received on the wide beam in the 0-40 m zone to saturate. Without a reliable voltage value on both narrow and wide beams, target strength cannot be estimated. At this point, the cause of the hydroacoustic noise encountered remains unknown. An error in programmed ESP parameters also caused echoes beyond 100 m to be rejected. Equipment calibration in spring 1994 revealed faulty summing amplifiers in the echosounder used on the left bank. The summing amplifiers were configured such that wide and narrow channels were amplified unequally, resulting in a +5.5 dB shift in beam pattern factor. This accounts for most of the over axis echoes shown in Figure 7. Given this information, it may be possible to reclaim some of the left bank dual-beam data for target strength analysis.

Transects

It is clear at this point that the assumption of uniform lateral distribution in the river's cross-section is not valid (Figure 10). Fish tended to be bank oriented throughout the season. In 1993, assigning the mean passage of all ensonified sectors to the middle portion of the river that was unensonified overestimated the passage in the unensonified zone to an unknown extent, while passage in the 0-40 m zone on the right bank was likely underestimated. Thus, these two errors offset each other to some unknown degree.

Species Apportionment

The close agreement of sonar passage estimates with Bethel test fishery CPUE for chinook, sockeye and chum salmon indicates that the size distribution of fish detected by sonar was adequately sampled by the test fishery during the period from early June through mid-to-late

July. It should also be noted that estimated chinook, sockeye, and chum salmon passage dropped after the commercial fishing period in late June, as did CPUE. A sharp increase in chum salmon daily CPUE in early July (Figure 13) that was not mirrored by sonar passage coincided with strong upstream winds that may have increased catchability. Strong upstream winds have in the past appeared to bring migrating fish to the surface, possibly to take advantage of slower current retarded by the wind. The sudden upswing in daily chinook salmon passage estimates from 24 July to 29 July (Figure 11) was due to a small sample size of fish caught in the drift gillnets on these dates, of which a few were chinook salmon. Because these fish were caught in the 16.5 cm (6.5 in) and 10.2 cm (4.0 in) mesh nets, the Bethel test fishery index showed no increase in chinook CPUE. It is possible that cisco passage at this time kept sonar daily passage estimates high relative to test fishery catches, artificially magnifying the pulse of chinook salmon estimated. Sonar passage estimates cannot be independently corroborated by Bethel test fishery CPUE data. Both mesh sizes used in the Bethel test fishery project are also used in species apportionment. However, the noticeable difference between sonar and test fishery CPUE patterns in coho salmon (Figure 14) shows that the Bethel test fishery CPUE is sufficiently independent of passage estimates to have some corroborative value for sonar passage estimates.

RECOMMENDATIONS

1. It is recommended that fathometer transects be used to estimate fish passage in the unensonified zone. It is clear that fish passage is not uniformly distributed across the river width.

2. It is recommended that set gillnets be used for species apportionment in the near-shore zone (0-40 m). This will improve accuracy of estimated species passage in the near-shore zone. It should also improve the accuracy of coho salmon passage estimates by providing estimates of cisco passage in this zone.

3. It is recommended that a 7.0 cm (2.75 in) mesh gillnet be added to the suite of meshes fished in the drift gillnet test fishery to provide estimates of cisco passage. This, together with species apportionment in the 0-40 m zone, should improve accuracy of apportionment between coho salmon and ciscos.

4. It is recommended that mesh sizes in the set gillnet test fishery be changed to match that of the drift gillnet fishery. The present suite of meshes fished in the near-shore zone is biased toward the catch of small fish. Although the largest mesh fished was only 15.1 cm (5.5 in), about 6% of the near-shore catch was chinook salmon. This mesh is only about half as efficient as a 20.3 cm (8.0 in) mesh at catching chinook salmon greater than 650 mm (Figure 2). Using the 16.5 cm (6.5 in) and 20.3 cm (8.0 in) meshes in place of the 12.7 cm (5.0 in) and 15.1cm (5.5 in) mesh sizes will better estimate species composition, because it will more representatively sample the full range of fish lengths present.

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Mulligan, T.J., and Kieser, R. 1986. Comparison of acoustic population estimates of salmon in a lake with a weir count. Can. J. Fish. Aquat. Sci., 43: 1373-1385.

Table 1. Dual-beam sampling schedule for Kuskokwim River sonar project, 1993.

Time (hours)	Bank
0130 - 0330	Right
0330 - 0530	Left
0530 - 0730	Right
0730 - 0930	Left
0930 - 1130	Right
1130 - 1330	Left
1330 - 1500	Right
1530 - 1730	Left
1730 - 1930	Right
1930 - 2130	Left
2130 - 2330	Right
2330 - 0130	Left

Table 2. Sonar system parameters used during the 1993 season for the Kuskokwim River sonar project.

Right Bank Sounder Settings	Left Bank Sounder Settings
3 June - 17 June	*20 June - 24 June*
• Range 180 meters	• Range 75 meters
• Ping rate 4.0 sec^{-1}	• Ping rate 5.0 sec^{-1}
• Chart recorder threshold 600	• Chart Recorder threshold 230
• Receiver gain -12 db	• Receiver gain -18 db
• Transmit power -13 db	• Transmit power -3 db
• Pulse width .4 mSec	• Pulse width .4 mSec
• Blank at distance engaged	• Blank at distance engaged
11 June - 20 August	*24 June - 20 August*
• Range 40 meters	• Range 40 meters
• Ping rate 4.0 sec^{-1}	• Ping rate 5.0 sec^{-1}
• Chart recorder threshold .5	• Chart recorder threshold .5
• Target strength threshold (see Table 4)	• Target strength threshold -52.4 dBv
• Receiver gain 0 db	• Receiver gain 0 db
• Transmit power -6 db	• Transmit power -6 db
• Pulse width .4	• Pulse width .4
• Normal was engaged	• Normal was engaged

Table 3. Voltage threshold with range as set in ESP software for the right bank, Kuskokwim River sonar project, 1993.

0 - 40	7.253
40 - 50	4.642
50 - 55	3.836
55 - 60	3.223
60 - 65	2.747
65 - 70	2.368
70 - 75	2.063
75 - 80	1.813
80 - 85	1.606
85 - 90	1.433
90 - 95	1.286
95 - 100	1.160
100 - 105	1.053
105 - 110	0.959
110 - 115	0.877
115 - 120	0.806
120 - 125	0.743
125 - 130	0.687
130 - 135	0.637
135 - 140	0.592
140 - 145	0.552
145 - 150	0.516
150 - 155	0.483
155 - 160	0.453
160 - 165	0.426
165 - 170	0.402
170 - 175	0.379
175 - 180	0.350

Table 4. Effective target strength threshold (on MRA) with range resulting from 0.5 V threshold set on right bank chart recorder, Kuskokwim River sonar project, 1993.

Range (m)	Threshold (dBv)
0-40	-64.2
50	-60.8
60	-57.7
70	-55.0
80	-52.7
90	-50.6
100	-48.8
110	-47.1
120	-45.6
130	-44.2
140	-43.0
150	-41.8
160	-40.6
170	-39.6
180	-38.6

Table 5. Drift schedule used to determine sequence (in parentheses) of stations and mesh sizes (in) fished during each tidal drift series of the 1993 Bethel test fishery when 8.0, 6.5, 5.4, and 4.0 in mesh sizes were in use.

Schedule Number	Station Number		
	1	2	3
1	8.0 (1)		8.0 (2)
		5.4 (3)	5.4 (4)
	6.5 (5)		6.5 (6)
	4.0 (8)	4.0 (7)	
2	8.0 (1)	8.0 (2)	
	5.4 (4)		5.4 (3)
		6.5 (5)	6.5 (6)
	4.0 (7)		4.0 (8)
3		8.0 (1)	8.0 (2)
	5.4 (3)	5.4 (4)	
	6.5 (6)		6.5 (5)
		4.0 (7)	4.0 (8)
4		8.0 (1)	8.0 (2)
		5.4 (4)	
		5.4 (4)	5.4 (3)
	6.5 (5)	6.5 (6)	
	4.0 (8)		4.0 (7)
5		8.0 (1)	8.0 (2)
	5.4 (3)		5.4 (4)
		6.5 (5)	6.5 (6)
	4.0 (7)	4.0 (8)	
6	8.0 (1)		8.0 (2)
	5.4 (4)	5.4 (3)	
	6.5 (6)	6.5 (5)	
		4.0 (8)	4.0 (7)

Table 6. Drift schedule used to determine sequence (in parentheses) of stations and mesh sizes (in) fished during each tidal drift series of the 1993 Bethel test fishery when 6.5, 5.4, and 4.0 in mesh sizes only were in use.

Schedule Number	Station Number 1	2	3
1	5.4 (1)	5.4 (2)	5.4 (3)
	6.5 (4)		6.5 (5)
	4.0 (7)	4.0 (6)	
2	5.4 (3)	5.4 (1)	5.4 (2)
		6.5 (4)	6.5 (5)
		4.0 (6)	4.0 (7)
3	5.4 (2)	5.4 (3)	5.4 (1)
	6.5 (5)		6.5 (4)
		4.0 (6)	4.0 (7)
4	5.4 (1)	5.4 (3)	5.4 (2)
	6.5 (4)	6.5 (5)	
	4.0 (7)		4.0 (6)
5	5.4 (2)	5.4 (1)	5.4 (3)
		6.5 (4)	6.5 (5)
	4.0 (6)	4.0 (7)	
6	5.4 (3)	5.4 (2)	5.4 (1)
	6.5 (5)	6.5 (4)	
		4.0 (7)	4.0 (6)
		4.0 (8)	4.0 (7)

Table 7. Mesh sizes used to determine relative abundance of fish species present at the Kuskokwim River sonar site, 1993. Small chinook are defined as < 640 mm, large chinook ≥ 640 mm.

	Gillnet Mesh Size (in)			
Species	4.0	5.4	6.5	8.0
Large Chinook		X	X	X
Small Chinook		X	X	
Sockeye		X	X	
Chum		X	X	
Pink	X	X		
Coho		X	X	
Whitefish	X	X		

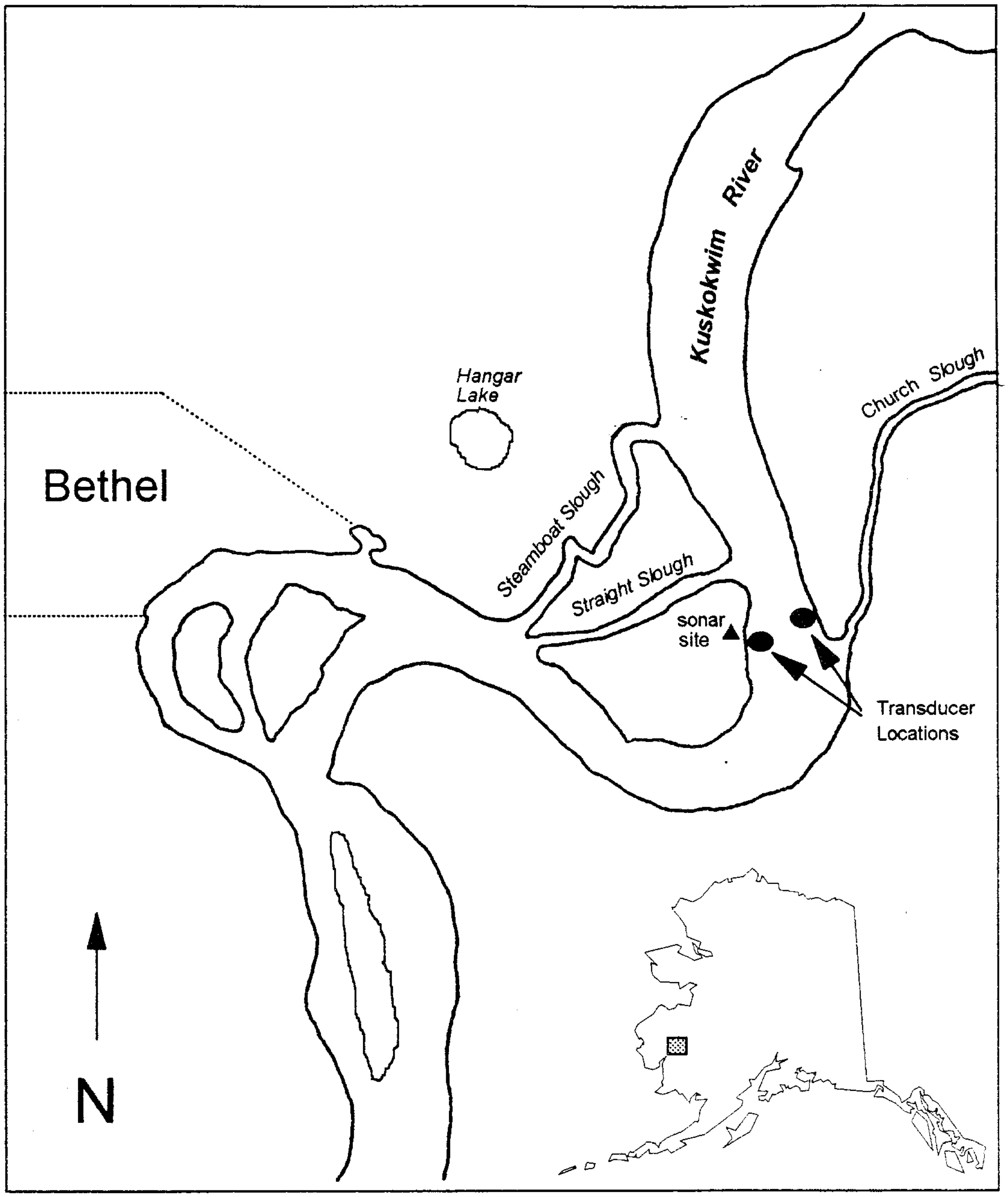


Figure 1. Map of the Kuskokwim River showing location of the 1993 sonar site.

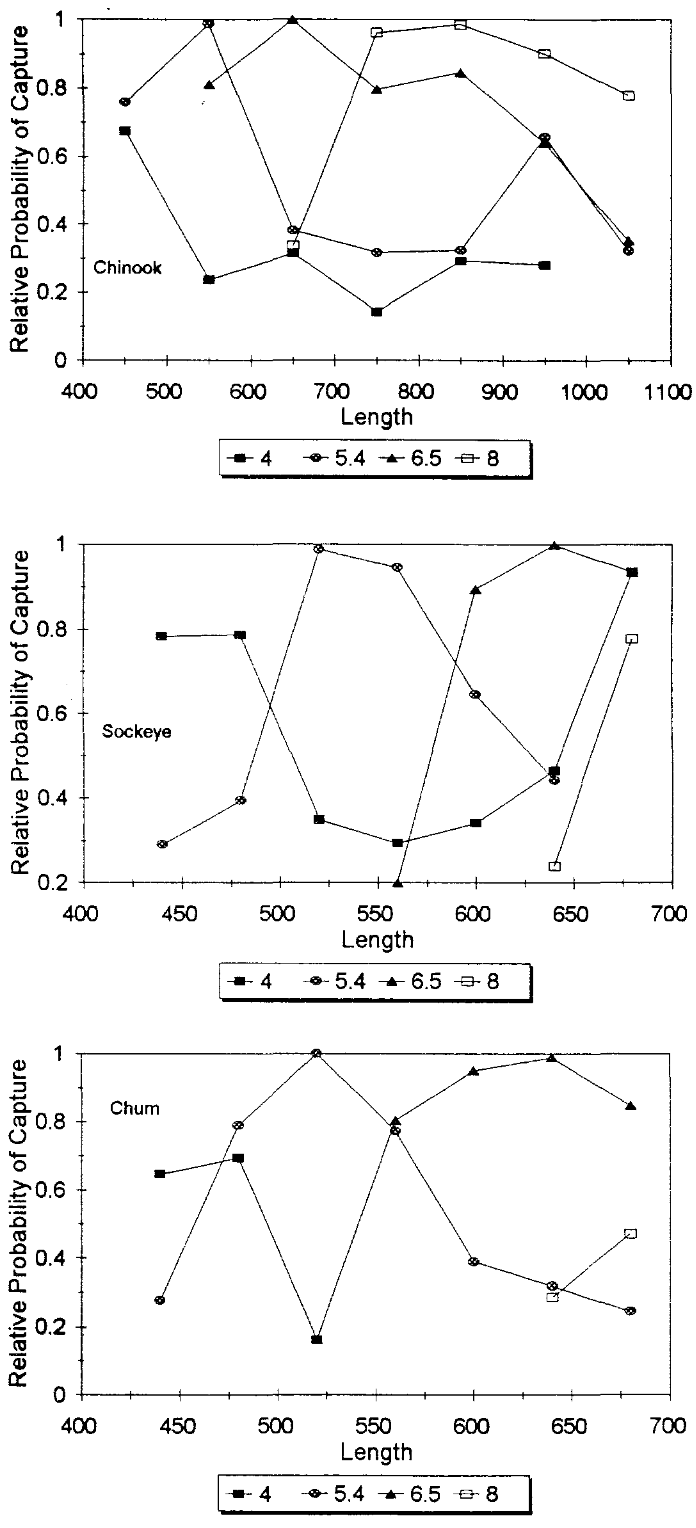


Figure 2. Net selectivity curves for gillnet mesh sizes (in) used for species apportionment for chinook, sockeye, and chum salmon at the Kuskokwim River sonar project, 1993.

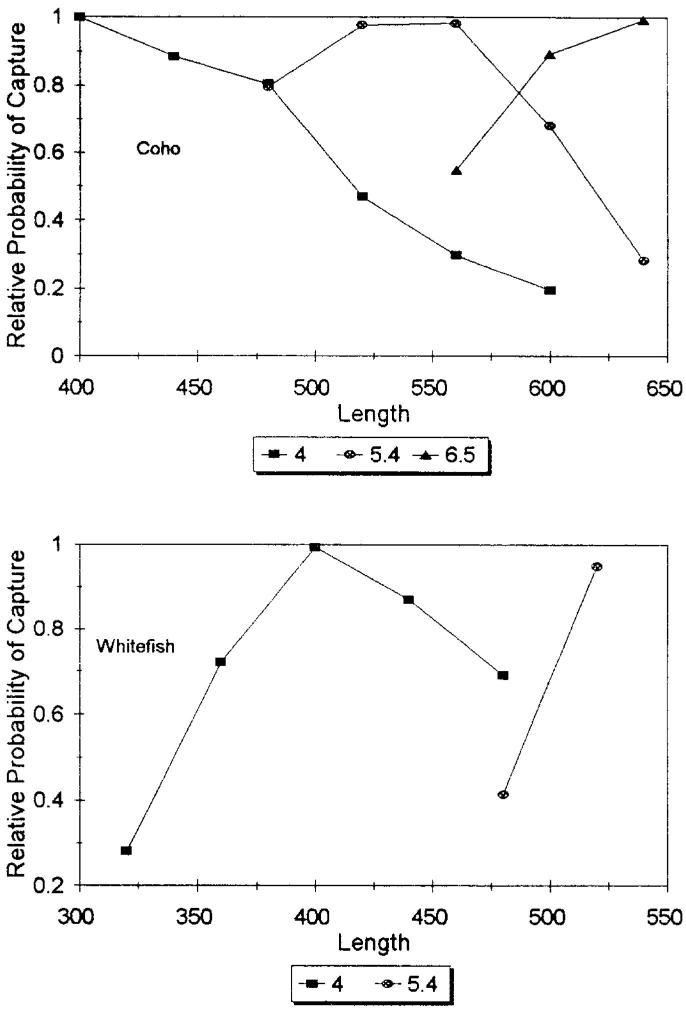


Figure 3. Net selectivity curves for gillnet mesh sizes (in) used for species apportionment of coho salmon and whitefish at the Kuskokwim River sonar project, 1993.

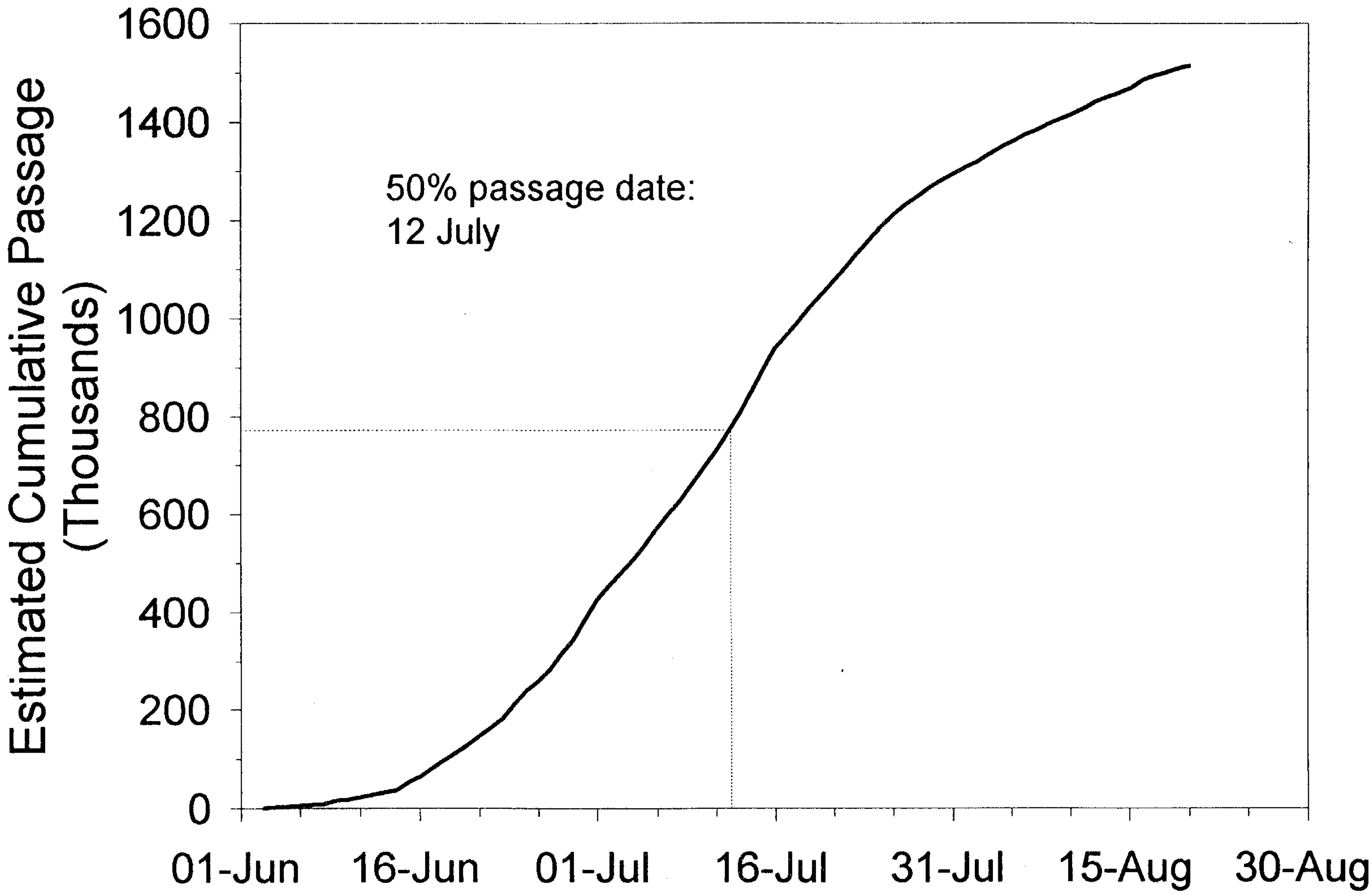


Figure 4. Cumulative passage of all species, Kuskokwim River sonar project, 1993.

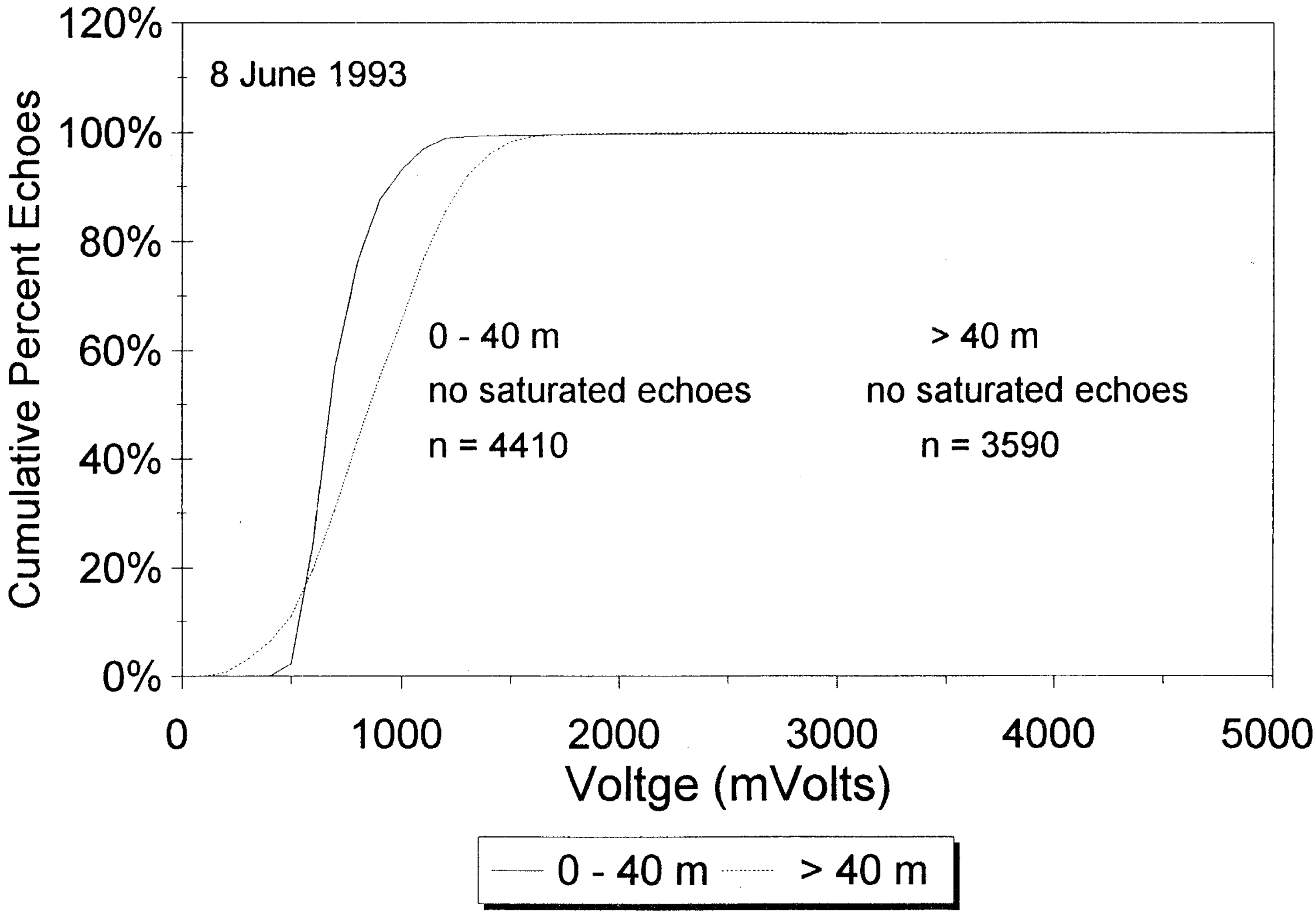


Figure 5. Saturation level of echoes on 8 June from the 0-40 m zone on the right bank where TVG amplification was operative, and >40 m, where TVG did not increase with range, Kuskokwim River sonar project, 1993.

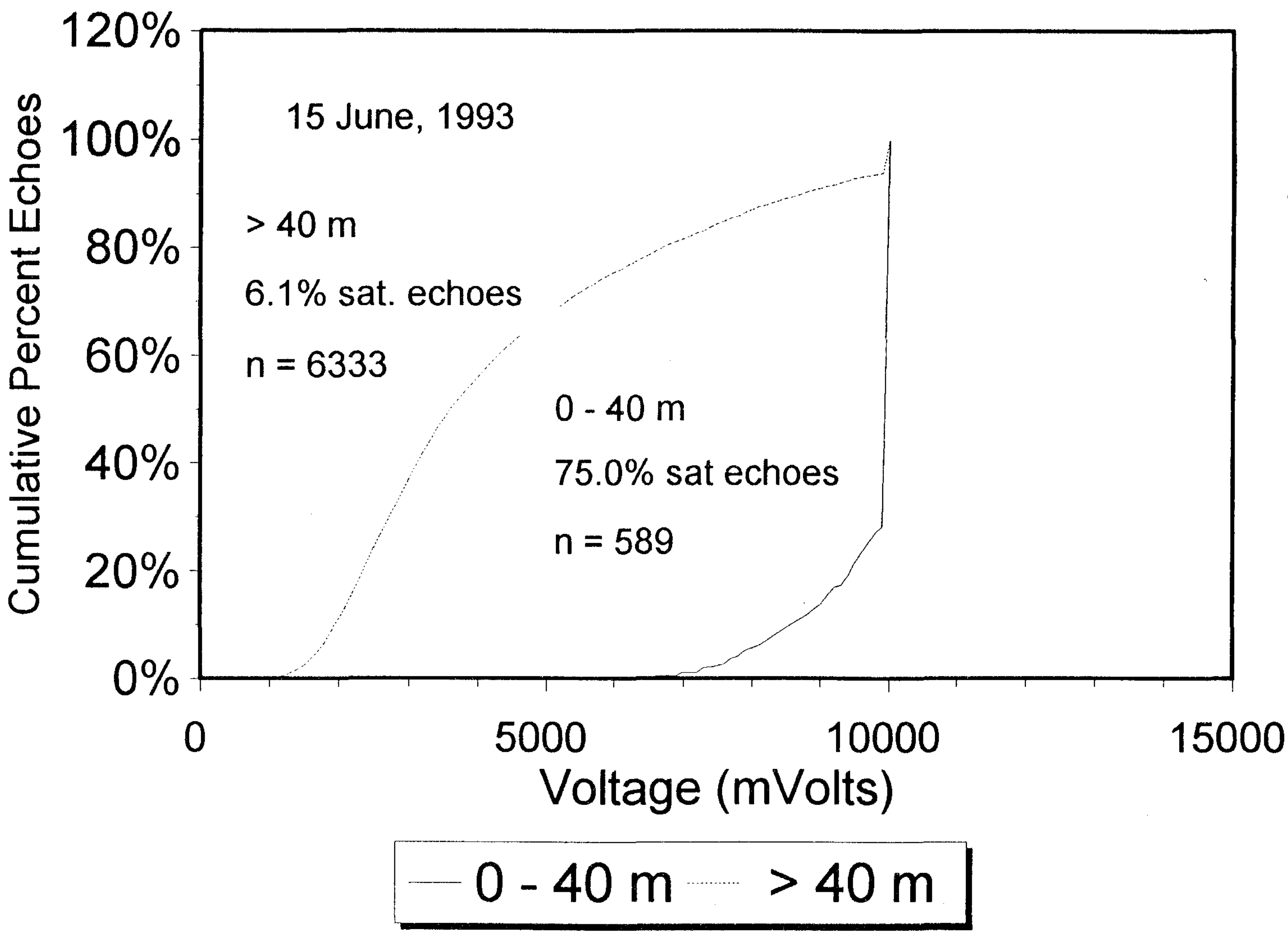


Figure 6. Saturation level of wide-beam echoes on 15 June from the 0-40 m zone on the right bank wh amplification was operative, and >40 m, where TVG did not increase with range, Kuskokwim River sonar project, 1993.

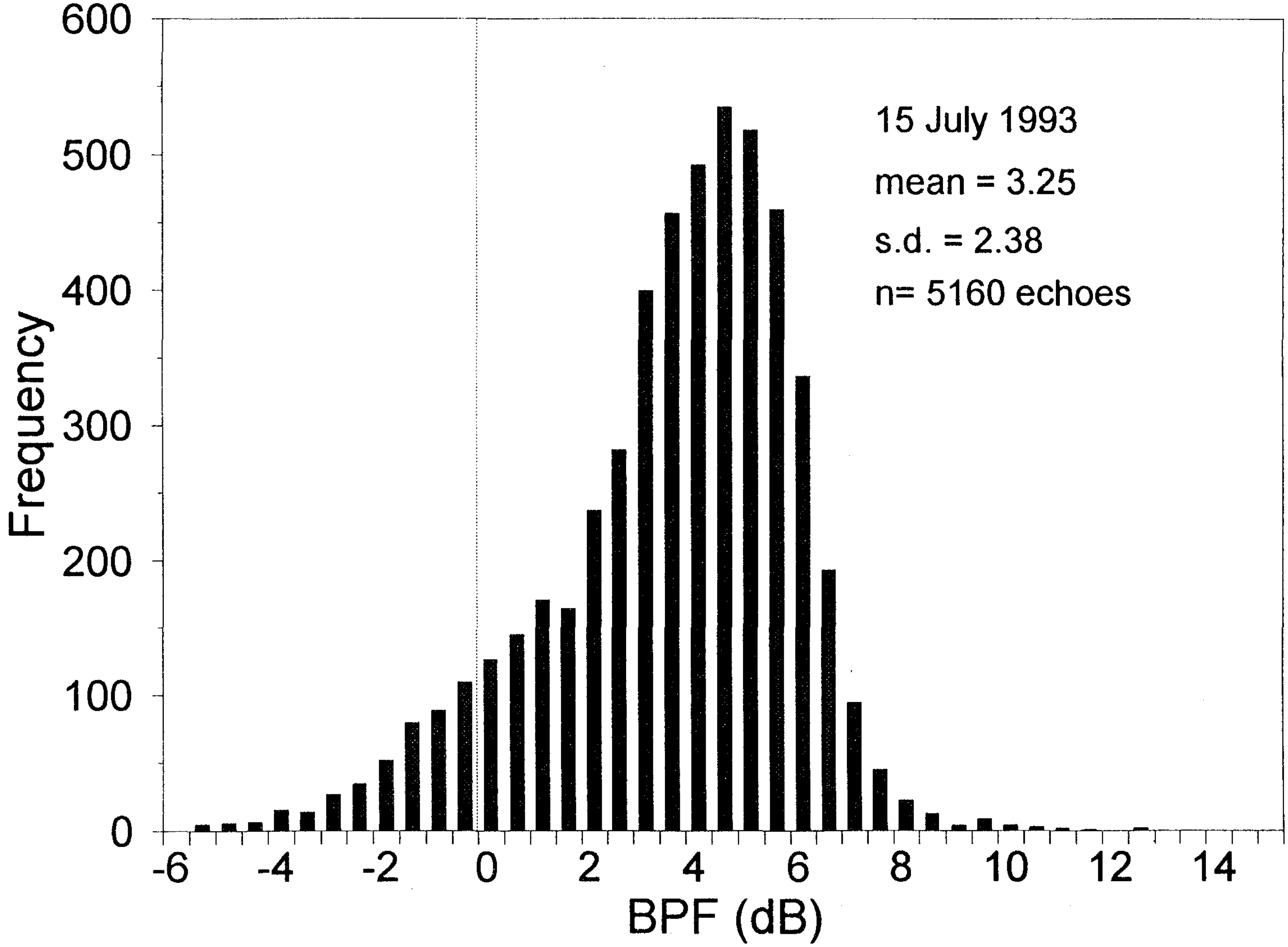


Figure 7. Histogram of echo beam pattern factors for the left bank, Kuskokwim River sonar project, 1993.

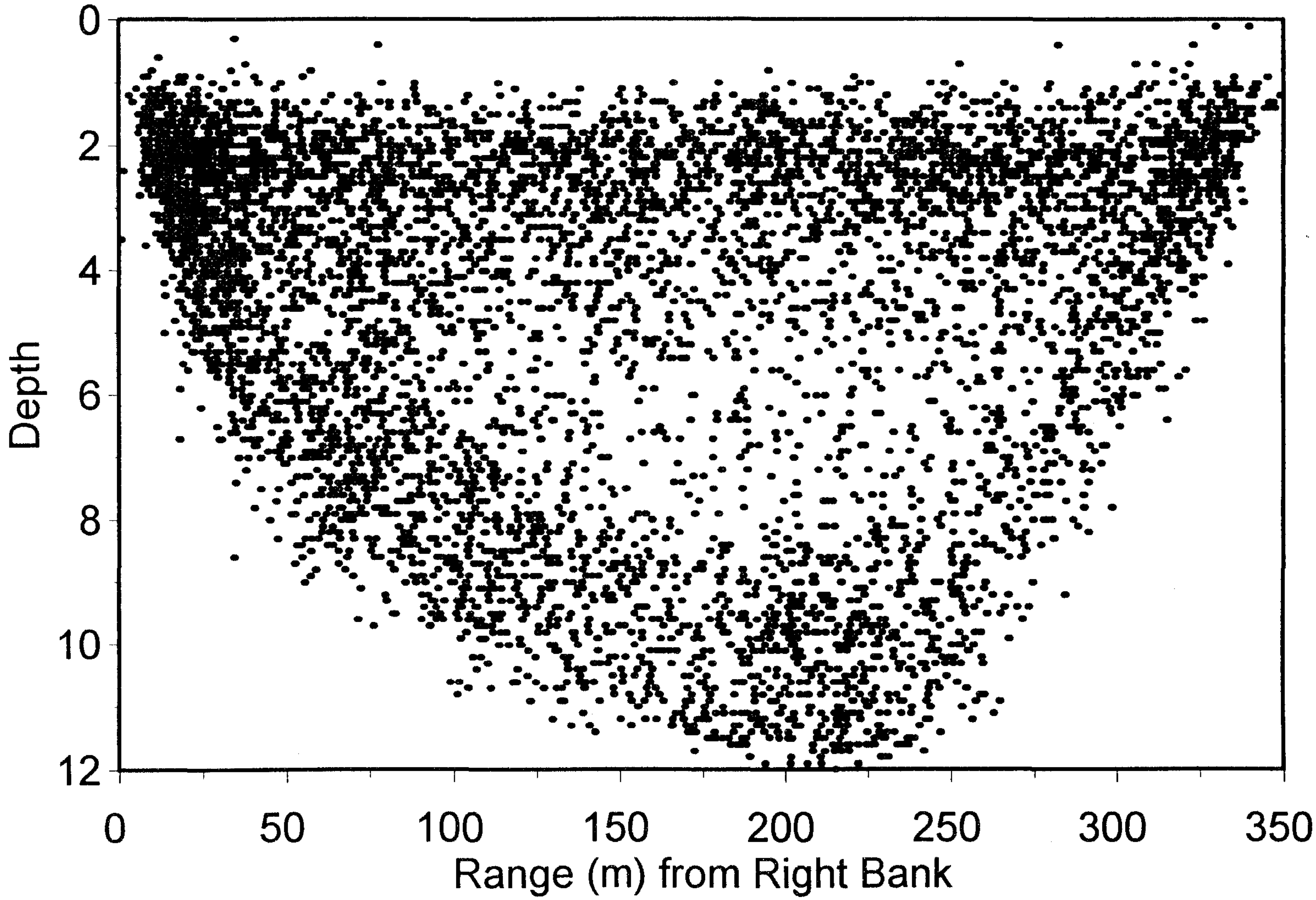


Figure 8. Cross-sectional distribution of fish from fathometer transects (unadjusted for variable probability of detection with depth), Kuskokwim River sonar project, 1993.

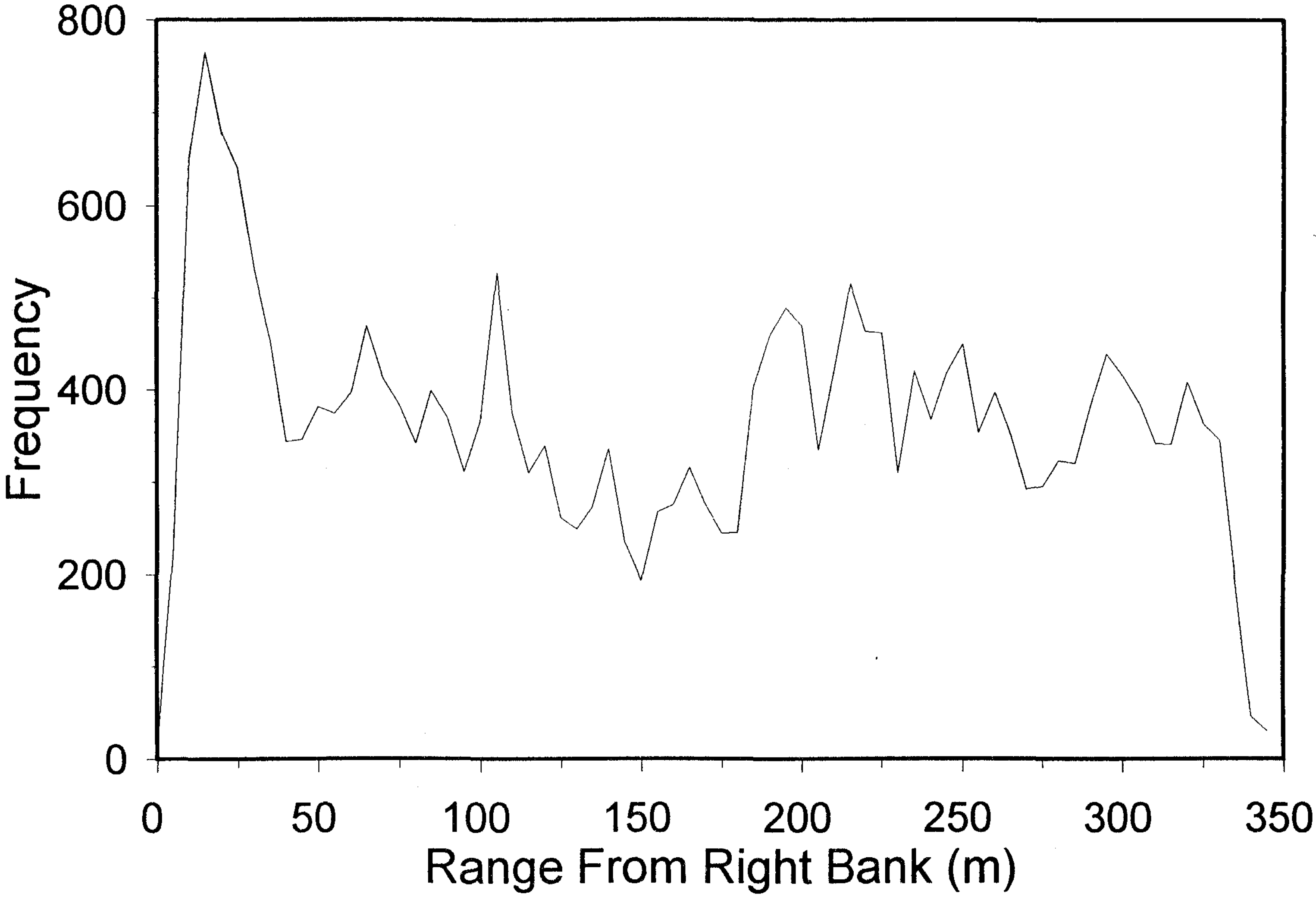


Figure 9. Seasonal distribution of fish from transect data, corrected for variable probability of detection with depth, Kuskokwim River sonar project, 1993.

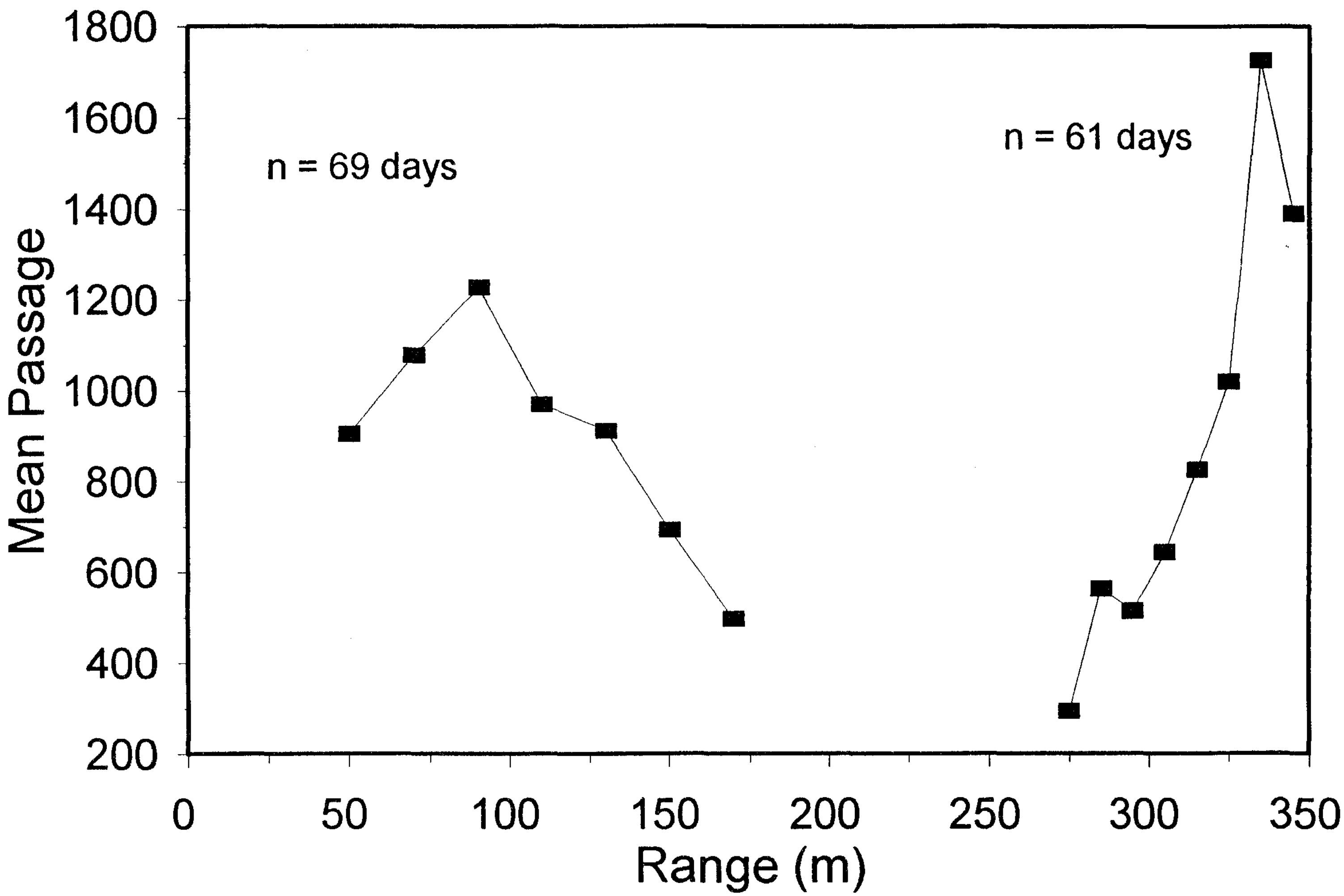
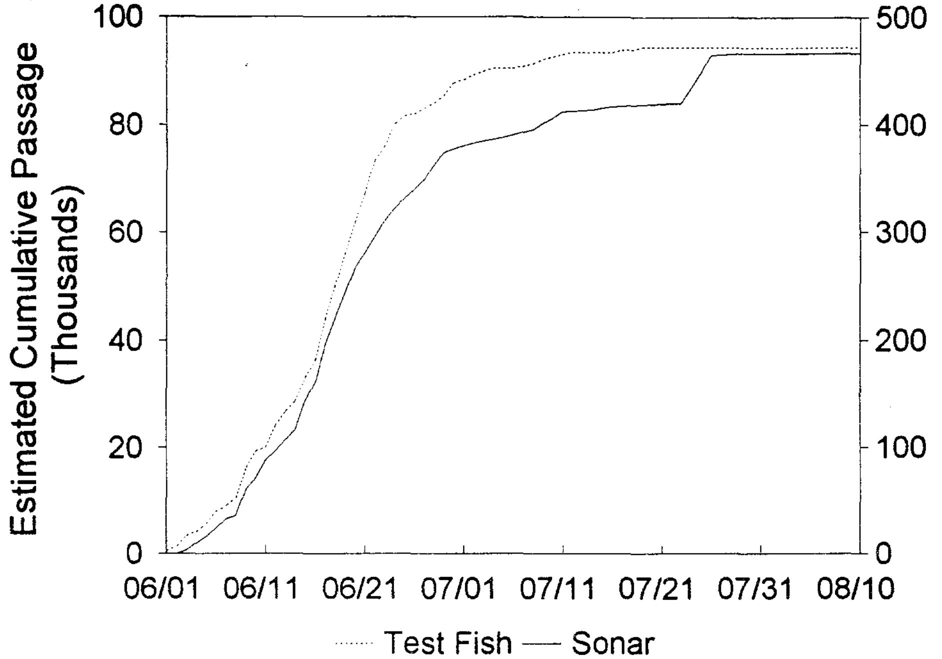


Figure 10. Range distribution of fish from side-looking sonar data, Kuskokwim River sonar project, 1993



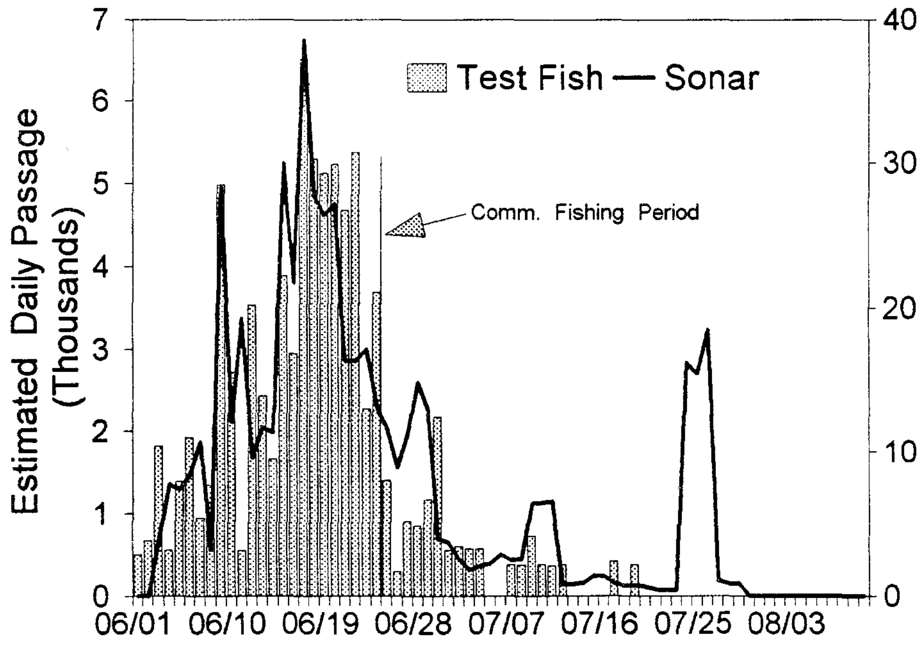
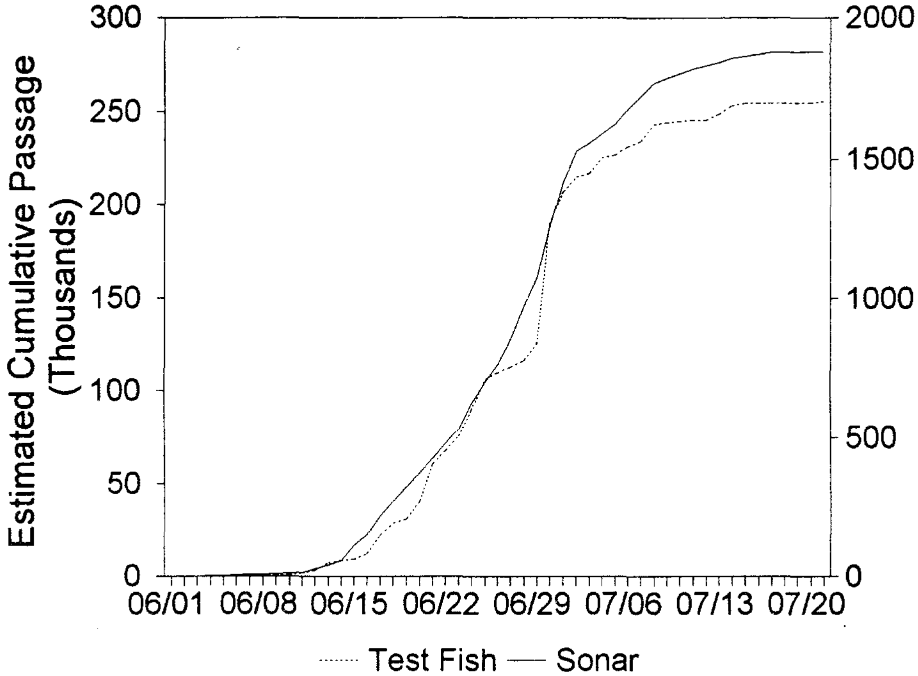


Figure 11. Comparison of daily and cumulative passage of chinook salmon as estimated by the Kuskokwim River sonar project and daily and cumulative CPUE in the Bethel test fishery, 1993.



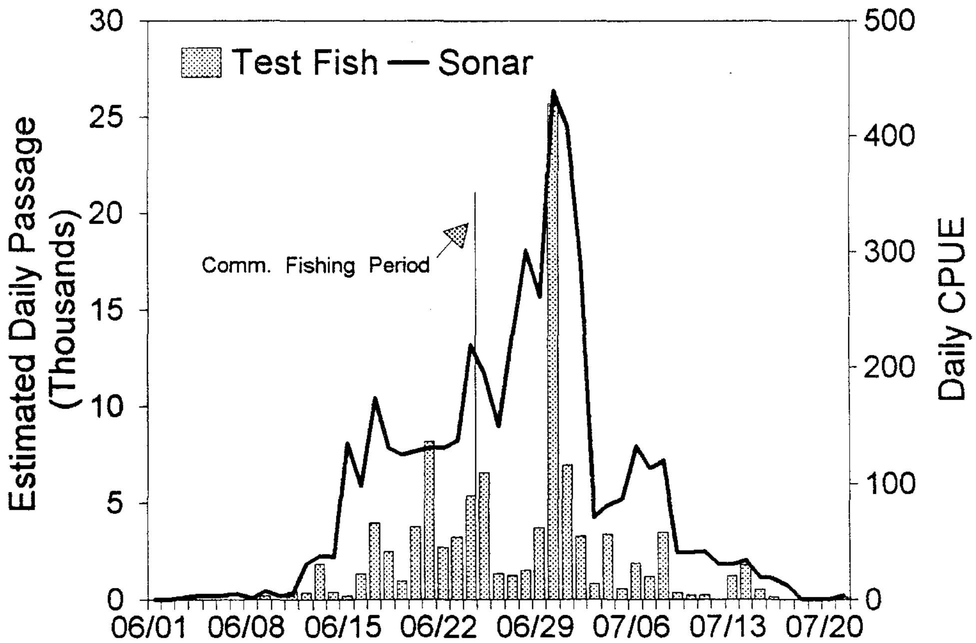
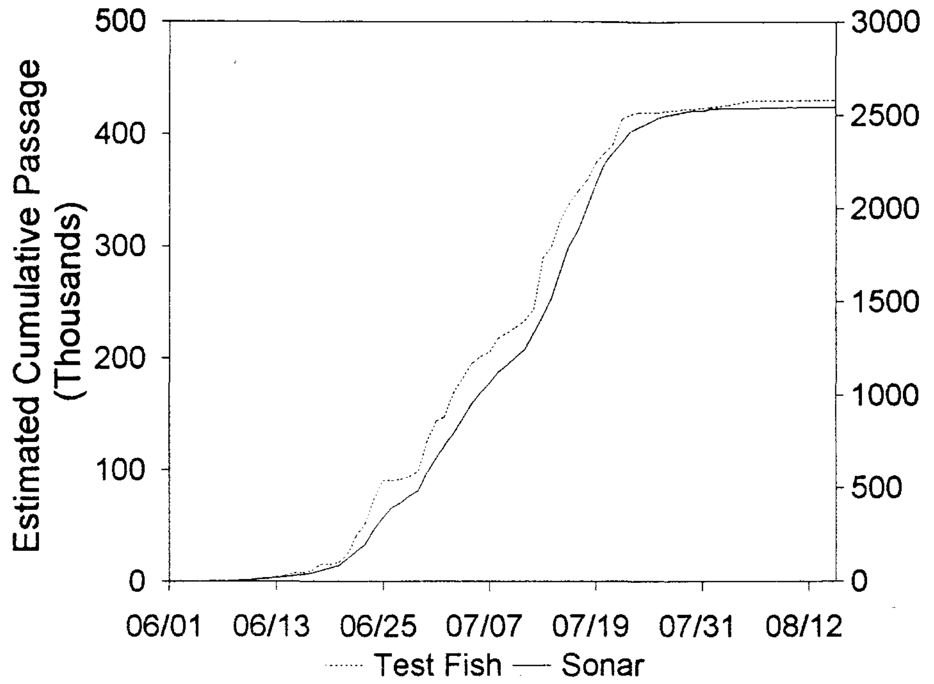


Figure 12. Comparison of daily and cumulative passage of sockeye salmon as estimated by the Kuskokwim River sonar project and daily and cumulative CPUE in the Bethel test fishery, 1993.



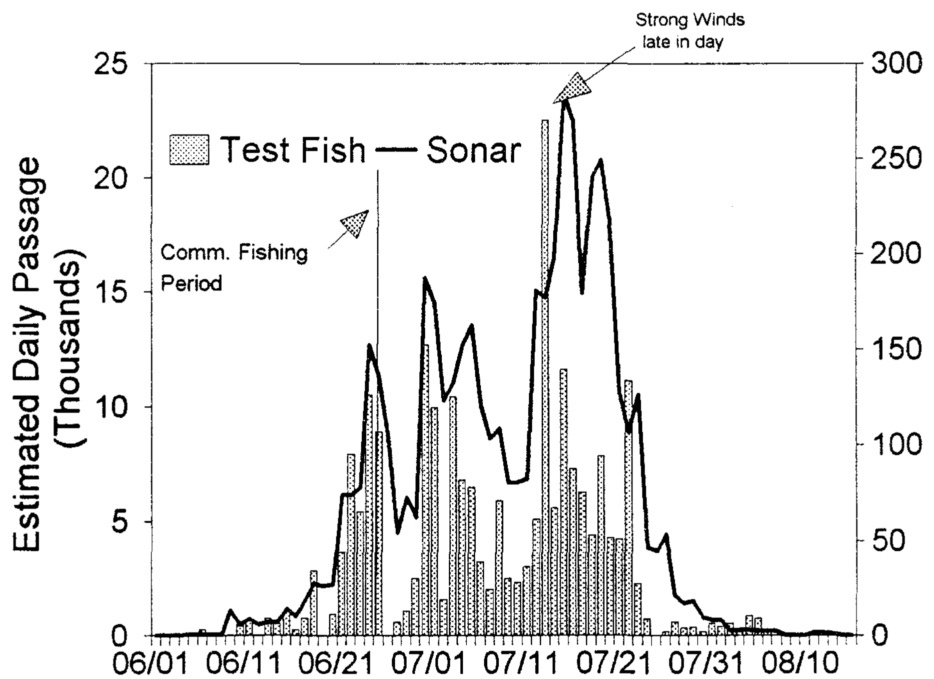
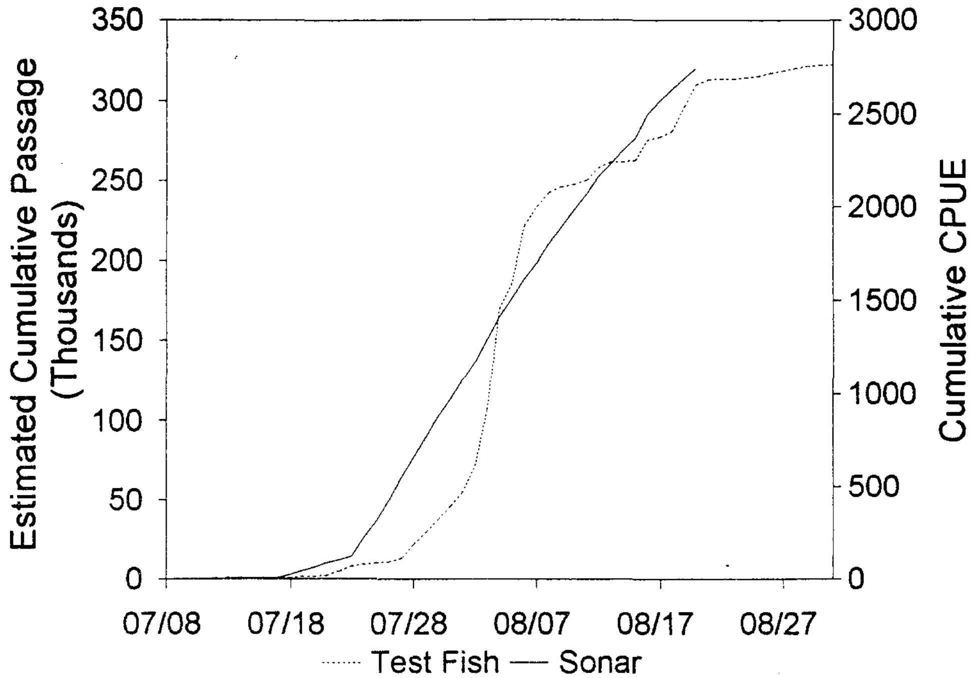


Figure 13. Comparison of daily and cumulative passage of chum salmon as estimated by the Kuskokwim River sonar project and daily and cumulative CPUE in the Bethel test fishery, 1993.



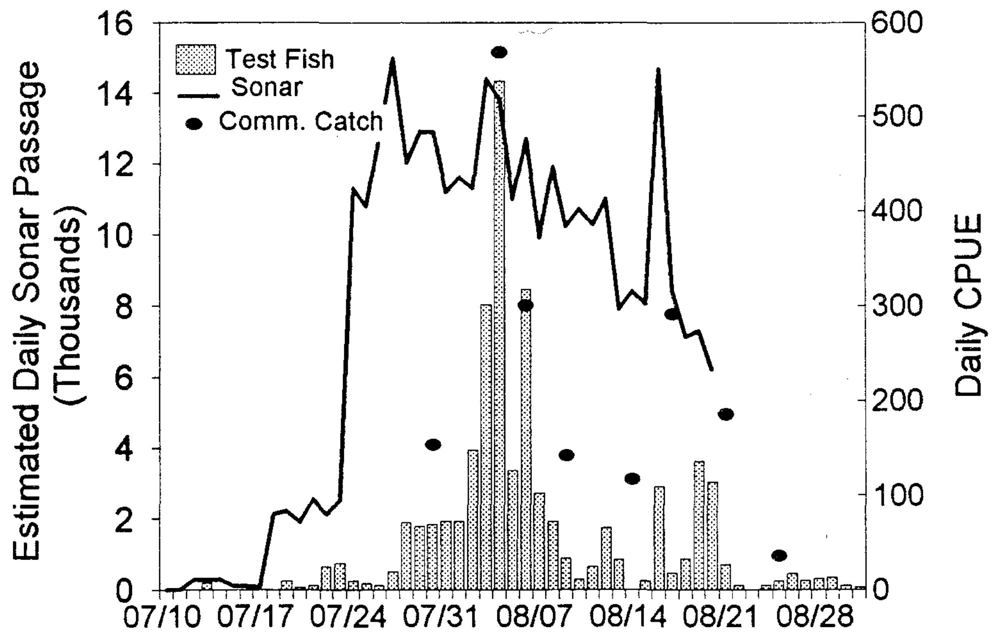


Figure 14. Comparison of daily and cumulative passage of coho salmon as estimated by the Kuskokwim River sonar project and daily and cumulative CPUE in the Bethel test fishery, 1993. Daily graph also shows commercial catch for statistical area 335-13. Commercial catch is divided by 3.38 to allow plotting on daily sonar passage axis.

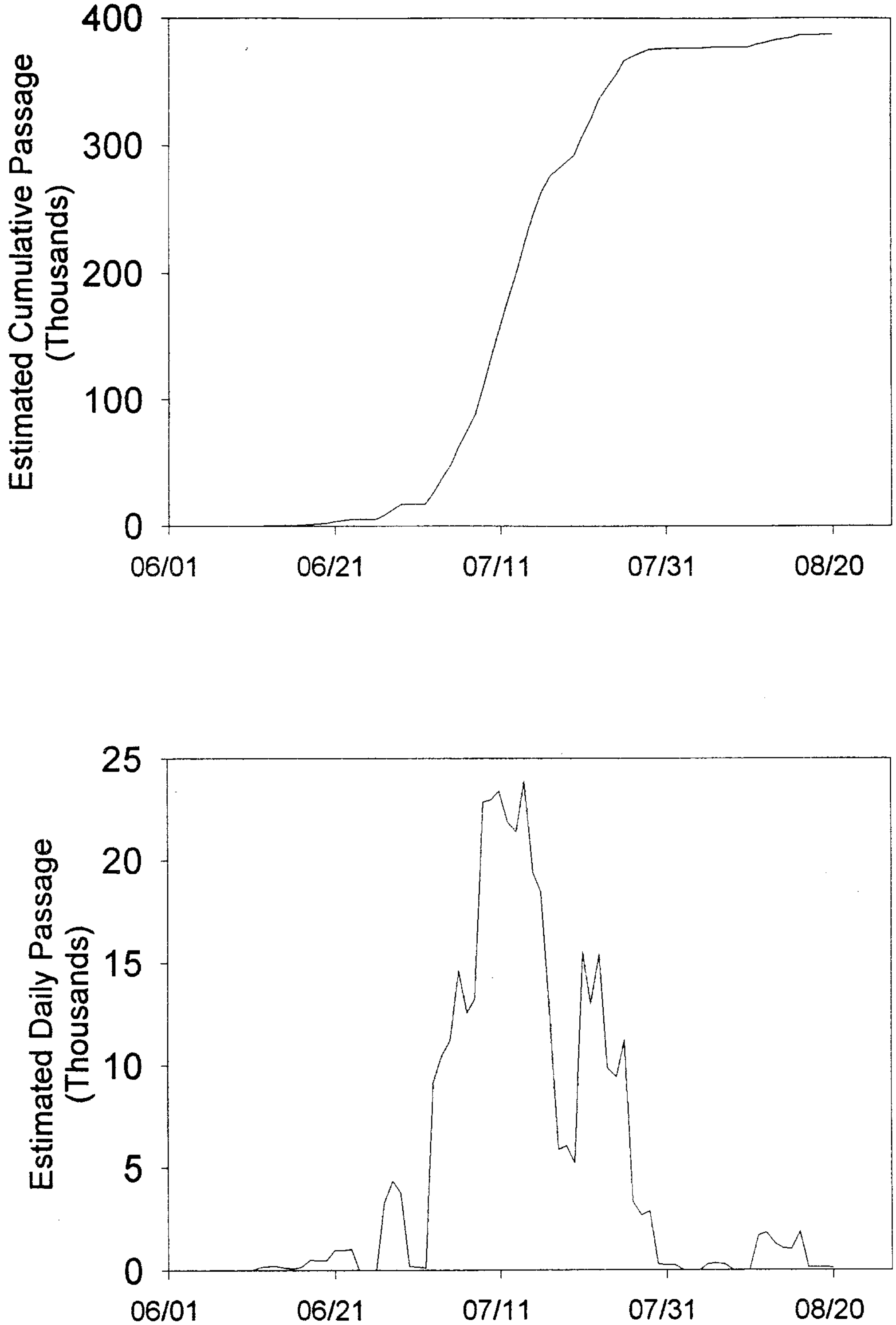


Figure 15. Daily and cumulative passage of whitefish estimated by the Kuskokwim River sonar project, 1993.

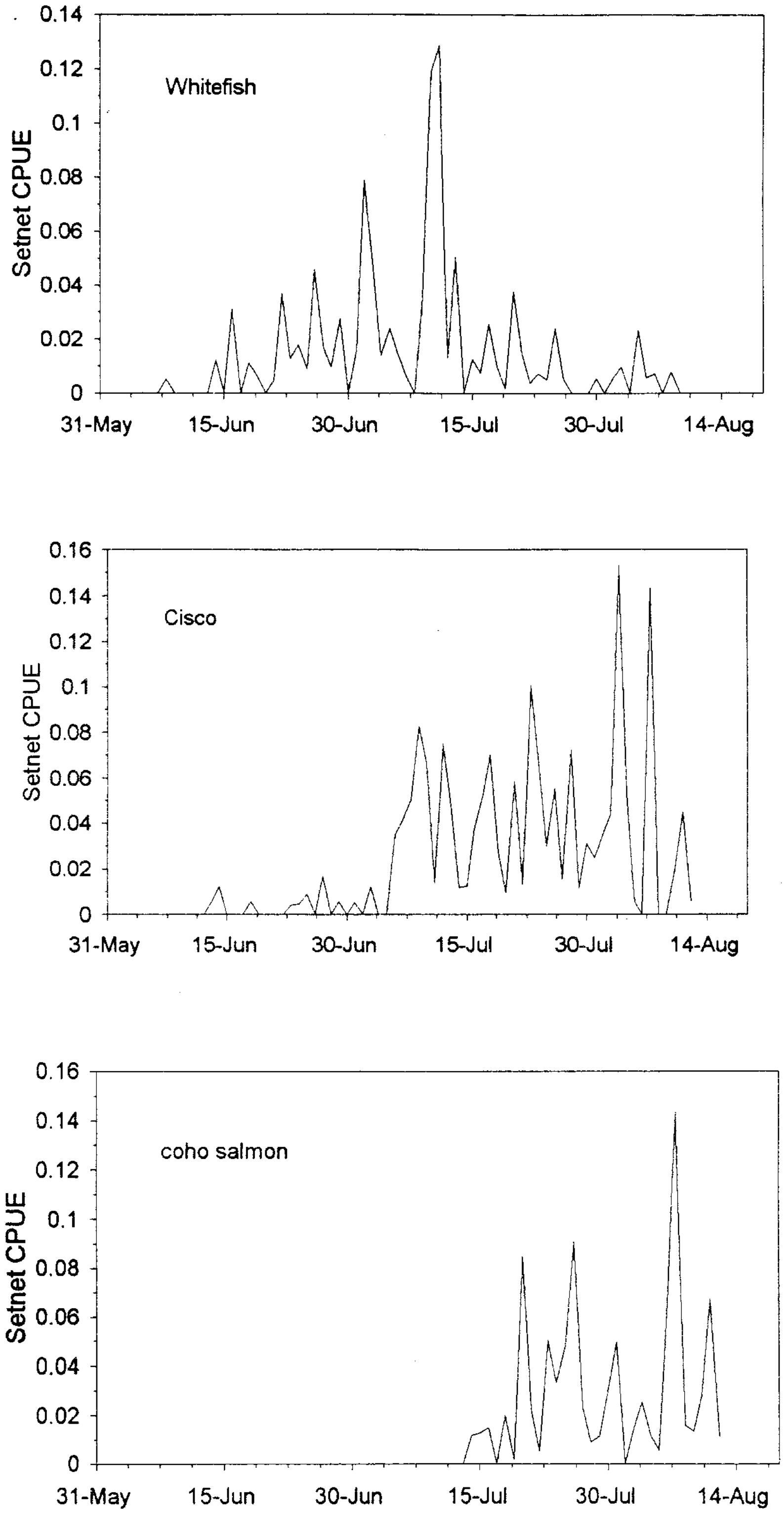


Figure 16. Set gillnet CPUE for whitefish, cisco, and coho salmon at the Kuskokwim River sonar project, 1993.

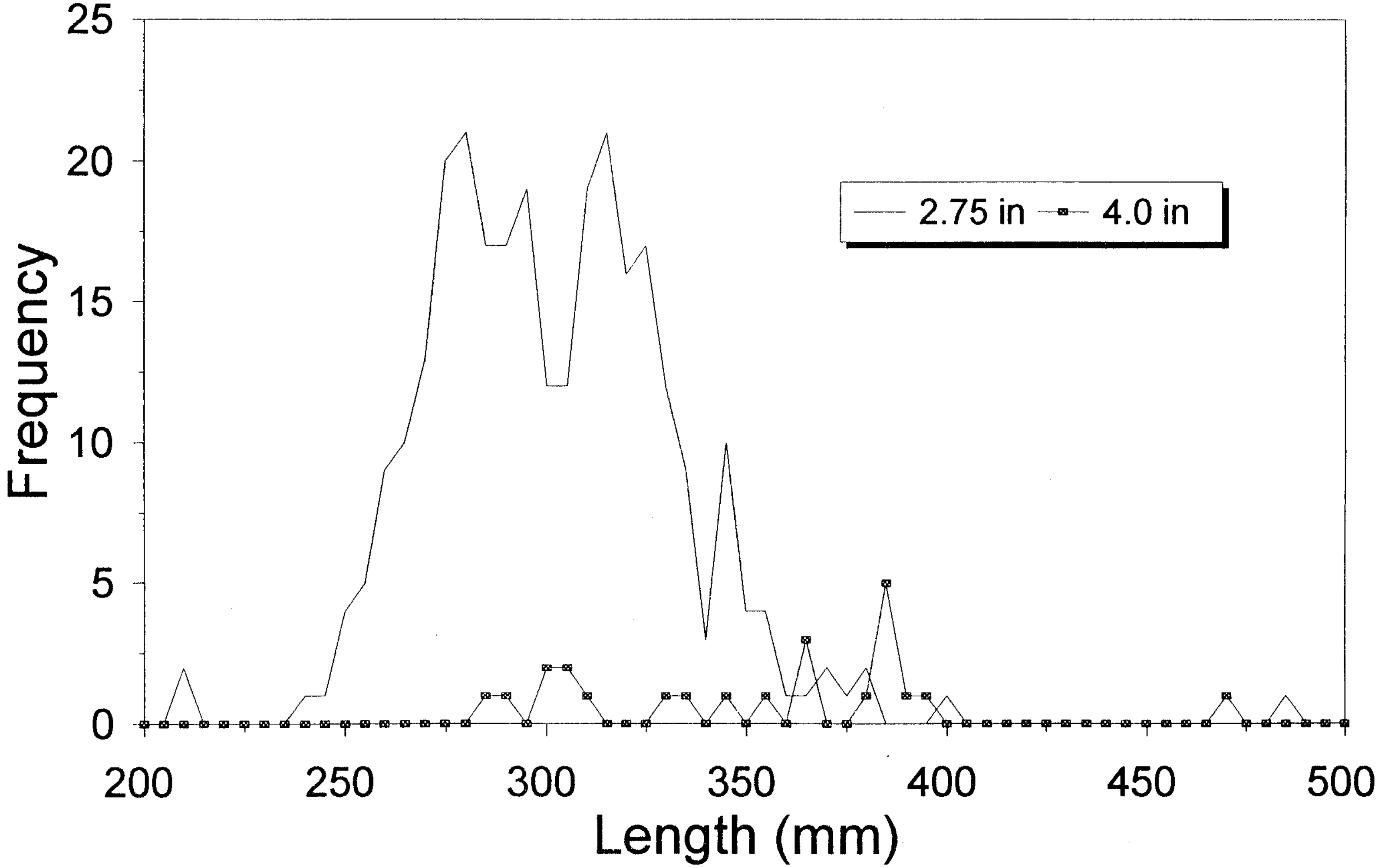


Figure 17. Size distributions of cisco caught in 2.75 in and 4.0 in set nets at the Kuskokwim River sonar site, 1993.

Appendix A.1. SAS 6.0 code (BTF93.SAS) used to estimate species proportions and passage by species.

```
*BTF93.SAS: USES BETHEL TESTFISH DATA TO APPORTION OFFSHORE FISH COUNTS
 FROM 1993 KUSKOKWIM SONAR.
 DIFFERS FROM BTF.SAS (1991/92) IN THAT ONLY OFFSHORE COUNTS ARE APPORTIONED;

title1 'Kuskokwim River Sonar Species Apportionment Programs:  BTF93.SAS';
options linesize=120 pagesize=47;

data offcnts;
  infile 'd:\runsasw\offcnt93.btf' firstobs=4;
  input report day month year dayoffps stdoffps;
  date =mdy(month,day,year);
  drop year month day;
  format date date7.;
  label dayoffps='OFFSHORE FISH' stdoffps='OFFSHORE FISH S.E.';
  run;

/*title2 'ESTIMATED OFFSHORE FISH PASSAGE, BY DAY';
proc print label data=offcnts;
  var report date dayoffps stdoffps;
  sum dayoffps;
  run;*/

proc sort data=offcnts; by report; run;
proc summary data=offcnts nway;
  var dayoffps; id stdoffps;
  output out=reptcnts sum=reptpasg;
  class report;
  run;

*READ DATA FROM RBASE EXPORT FILE, ONE LINE FOR EACH FISH, PLUS ONE LINE FOR
 ANY DRIFTS DURING WHICH NO FISH WERE CAUGHT;
*CALCULATE EFFORT IN FATHOM HOURS;
*NOTE THERE IS NO CONTINGENCY FOR DRIFTS SPANNING MIDNIGHT;
data testfish;
  length species $ 8;
  infile 'd:\runsasw\tfishdat.93' delimiter=',';
  informat date mmddyy. startout fullout startin fullin time8.;
  format date date7. startout time5.;
  input DUMMY date tide drift station mesh spcode length SEX $ fathoms
        startout fullout startin fullin;
  if fullout lt (startout-82800) then do;
    fullout=fullout+86400;
    startin=startin+86400;
    fullin=fullin+86400;
    end;
  if startin lt (fullout-82800) then do;
    startin=startin+86400;
    fullin=fullin+86400;
    end;
  if fullin lt (fullout-82800) then do;
    fullin=fullin+86400;
    end;
  drifmins = (startin-fullout)/60 + (fullout-startout)/(2*60) +
          (fullin-startin)/(2*60);
  drop fullout startin fullin;
  lclassmp= round(length,40);
  if spcode = 1 then do;
    if length=0 then lclassmp=0;
    else lclassmp= round(length+50,100)-50;
    if length gt 640 then species = 'CHINOOK ';
```

```
  if length le 640 then do;
    spcode = 8; species = 'JACK'; end;
   end;
 if spcode = 2 then species = 'SOCKEYE';
 if spcode = 3 then species = 'COHO';
 if spcode = 4 then species = 'PINK';
 if spcode = 5 then species = 'CHUM';
 if spcode = 6 then species = 'WHITE';
 if spcode = 7 then species = 'OTHER';
 if spcode = 0 or spcode = . then species = 'NONE';
 if mesh=2.5  then meshcode=1;
 if mesh=4.0  then meshcode=2;
 if mesh=5.4  then do;
                mesh=5.375;
                meshcode=3;
                end;
 if mesh=6.5  then meshcode=4;
 if mesh=8.0  then meshcode=5;
 run;

*COUNT THE NUMBER OF FISH OF EACH SPECIES IN EACH DRIFT;
proc sort data=testfish;
 by date tide drift;
 run;
proc summary data=testfish nway;
 by date tide drift;
 class mesh station startout species;
 var spcode;  id fathoms drifmins;
 output out=sppcatch n=sppcatch;
 run;

proc transpose data=sppcatch out=tfsummar;
 var sppcatch; id species;
 by date tide drift mesh station startout fathoms drifmins;
 run;

data spplist;
 chinook=0; jack=0; sockeye=0; chum=0; pink=0; coho=0; white=0; other=0;
 run;

data tfsummar; set tfsummar(in=a) spplist;
 if a;
 fathhrs= fathoms*drifmins/60;
 format date date7. startout time5. fathhrs 8.2;
 label fathhrs='FATHOM HOURS' drifmins='MEAN FISHING TIME';
 run;

proc sort data=tfsummar out=print; by date tide drift; run;
title2 'SUMMARY OF TESTFISH RESULTS, BY DRIFT';
proc print data=print label noobs;
 var date tide drift startout mesh station;
 sum fathhrs chinook jack sockeye chum pink coho white other;
 run;

data historic; set tfsummar(drop=startout pink white other);
 if mesh=5.375 or mesh=8.0 or drift=0;
 if chinook=. then chinook=0;  if jack=. then jack=0;
 if sockeye=. then sockeye=0;  if chum=. then chum=0;
 if coho=. then coho=0;
 chinook=chinook+jack;
```

```
 chincpue=100*(chinook)/fathhrs;
 sockcpue=100*sockeye/fathhrs;
 chumcpue=100*chum/fathhrs;
 cohocpue=100*coho/fathhrs;
 format chincpue sockcpue chumcpue cohocpue drifmins mesh 5.1 fathoms 3.0;
 label chincpue='CHINOOK CPUE' sockcpue='SOCKEYE CPUE' chumcpue='CHUM CPUE'
     cohocpue='COHO CPUE' chinook='CHINOOK CATCH' sockeye='SOCKEYE CATCH'
     chum='CHUM CATCH' coho='COHO CATCH';
 run;

title2 'CPUE BY DRIFT, 5.375" AND 8.0" MESH ONLY';
proc print data=historic noobs label;
 var date tide drift station mesh fathoms drifmins chinook chincpue
    sockeye sockcpue chum chumcpue coho cohocpue;
 sum chinook sockeye chum coho;
 run;

proc summary data=historic nway;
 var chinook chincpue;
 class date tide;
 output out=chintide sum(chinook)= mean(chincpue)=;
 run;

data smalmesh; set historic;
 if mesh=5.375;
 run;

proc summary data=smalmesh nway;
 var sockeye sockcpue chum chumcpue coho cohocpue;
 class date tide;
 output out=scctide sum(sockeye chum coho)=
                mean(sockcpue chumcpue cohocpue)=;
 run;

data histtide;
 merge chintide scctide;
 by date tide;
 format chincpue sockcpue chumcpue cohocpue 5.1;
 label chincpue='CHINOOK CPUE' sockcpue='SOCKEYE CPUE' chumcpue='CHUM CPUE'
     cohocpue='COHO CPUE' chinook='CHINOOK CATCH' sockeye='SOCKEYE CATCH'
     chum='CHUM CATCH' coho='COHO CATCH';
 run;

title2 'MEAN CPUE BY TIDE';
title3 'chinook 5.4" and 8" nets; sockeye, chum, and coho 5.4" net only';
proc print noobs label data=histtide;
 var date tide chinook chincpue sockeye sockcpue chum chumcpue coho cohocpue;
 sum chinook sockeye chum coho;
 run;

proc summary data=histtide nway;
 class date; var chincpue sockcpue chumcpue cohocpue;
 output out=histday sum=;
 run;

data histday; set histday;
 format chincpue sockcpue chumcpue cohocpue 5.1;
 label chincpue='CHINOOK CPUE' sockcpue='SOCKEYE CPUE' chumcpue='CHUM CPUE'
     cohocpue='COHO CPUE';
 run;
```

```
title2 'TIDAL CPUE SUMMED BY DAY';
proc print noobs label data=histday;
  var date chincpue sockcpue chumcpue cohocpue;
  run;

*SUM EFFORT FOR ALL DRIFTS WITH EACH MESH BY TIDE;
proc summary data=tfsummar nway;
  class date tide mesh;
  var fathhrs;
  output out=effort1 sum=meffort;
  run;

*FINALLY, REARRANGE DATA TO PUT EFFORTS FOR ALL MESHES ON A SINGLE LINE;
proc transpose data=effort1 out=effort2;
  var meffort; id mesh;
  by date tide;
  run;

*MERGE REPORT PERIOD NUMBER WITH TESTFISH DATA;
proc sort data=offcnts; by date; run;
data effort; merge effort2(drop=_name_ in=a) offcnts(keep=date report);
  by date;
  rename _2d5   =effort1;
  rename _4     =effort2;
  rename _5d375 =effort3;
  rename _6d5   =effort4;
  rename _8     =effort5;
  run;

*READ IN AN EXTERNAL FILE WHICH SETS WHICH MESHES WILL BE USED TO ESTIMATE
 CPUE FOR EACH SPECIES, AND WHICH SPECIES CATCHES WILL BE ADJUSTED FOR NET
 SELECTIVITY;
data specmesh;
  infile 'd:\runsasw\specmesh.93' firstobs=17;
  length species $ 8;
  length adjust $ 3;
  input species usemesh1-usemesh5 adjust;
  run;

*MERGE SPECIES-MESH PAIRING DATA INTO TESTFISH DATA SET;
*DELETE FISH WHICH WERE NOT CAUGHT IN MESHES TARGETING THAT SPECIES;
proc sort data=testfish; by species; run;
proc sort data=specmesh; by species; run;
data tfsm;
  merge testfish(in=a drop=fathoms drifmins) specmesh;
  by species;
  if a;
  if mesh=0 then delete;
  array usemesh{5} usemesh1-usemesh5;
  if usemesh{meshcode}=0 then delete;
  run;

*MERGE NET SELECTIVITY CURVE DATA INTO TESTFISH (+SM) DATA SET;
data netselec;
  infile 'd:\runsasw\netsel93.btf' missover firstobs=5;
  length species $8;
  input @5 species lclassmp 13-16 prob1 18-22 prob2 24-28 prob3 30-34
                          prob4 36-40 prob5 42-46;
  run;
```

```
proc sort data=tfsm; by species lclassmp; run;
proc sort data=netselec; by species lclassmp; run;
data tfsmns; merge tfsm(in=b) netselec; by species lclassmp;
 if b;
 run;

title2 'NET SELECTIVITY ESTIMATES USED TO ADJUST CATCHES';
proc print label noobs data=netselec; run;

*MERGE EFFORT DATA INTO TESTFISH (+SM+NS) DATA SET;
*DECLARE ARRAYS;
proc sort data=tfsmns; by date tide mesh; run;
data tfsmnsef; merge tfsmns(in=c) effort; by date tide;
 if c;
 array usemesh{5} usemesh1-usemesh5;
 array prob{5} prob1-prob5;
 array effort{5} effort1-effort5;
 *FOR MAJOR SPECIES, ADJUST CATCH (I.E., 1 FISH) FOR NET SELECTIVITY;
 *IF NET SELECTIVITY IS NOT KNOWN FOR THIS FISH, THEN SET CATCH TO ZERO;
 meanprob=0.7;
 if adjust='N' then adjcatch=1/meanprob;
 else if adjust='Y' then do;
   if prob{meshcode} ne . then adjcatch=1/prob{meshcode};
   else if prob{meshcode} eq . then adjcatch=0;
   end;
 *SUM EFFORT FOR ALL MESHES TARGETING THIS SPECIES DURING THIS TF PERIOD;
 *IF SPECIES IS ADJUSTED FOR NET SELECTIVITY, THEN DO NOT CONSIDER THOSE
  MESHES FOR WHICH NET SELECTIVITY IS NOT KNOWN FOR THIS FISH;
 *FINALLY, CALCULATE ADJUSTED CPUE FOR EACH FISH;
 sumeff=0;
 do imesh=1 to 5;
   if adjust='Y' then do;
     if prob{imesh} = . then usemesh{imesh}=0;
     end;
   if effort{imesh}=. then effort{imesh}=0;
   sumeff=sumeff+effort{imesh}*usemesh{imesh};
   end;
 adjcpue=adjcatch/sumeff;
 format date date7. startout time5.
       effort1-effort5 sumeff adjcatch 5.2;
 run;

*OPTIONAL PRINTOUT FOLLOWS: SHOWS INTERMEDIARY CALCULATIONS ON TESTFISH DATA;
data print; set tfsmnsef(obs=100);
title2 'PART OF DATA SET WORK.TFSMNSEF';
title3 'ONE LINE PER FISH, EACH LINE ALSO HAS INFORMATION ON NET SELECTIVITY';
title4 'CURVE PARAMETERS AND EFFORT FOR EACH MESH DRIFTED DURING THAT PERIOD';
 run;
 proc print data=print;
 var REPORT date tide drift startout station mesh species spcode lclassmp
     adjcatch usemesh1-usemesh5 effort1-effort5 sumeff adjcpue;
 run;

*SUM ADJUSTED CPUE FOR EACH SPECIES DURING EACH TESTFISH PERIOD;
proc summary data=tfsmnsef nway;
 class REPORT date tide spcode;
 var adjcpue adjcatch; id startout species;
 output out=spcpue sum=spcpue spcatch;
 run;
```

```
*TRANSPOSE BY ALL BUT SPECIES (CODE), CREATING A SEPARATE VARIABLE FOR CPUE OF
 EACH SPECIES;
proc transpose data=spcpue out=spcpwide;
 by REPORT date tide;
 var spcpue;
 id spcode;
 run;

proc summary data=spcpue nway;
 class REPORT date tide;
 var spcatch;
 output out=catch sum(spcatch)=adjcatch;
 run;

*SUM CPUE'S FOR ALL SPECIES DURING A GIVEN TESTFISH PERIOD;
data spcpwide; merge spcpwide catch; by REPORT date tide;
 array cpue{8} _1-_8;
 sumcpue=0;
 do i=1 to 8;
  if cpue{i} = . then cpue{i} = 0;
  sumcpue= sumcpue + cpue{i};
  end;
 format _1-_8 adjcatch sumcpue 6.2;
 run;

*SUM CPUE, FOR EACH SPECIES AND FOR ALL SPECIES, ACROSS ALL TIDES
 WITHIN EACH REPORTING PERIOD;
*CALCULATE THE AVERAGE TOTAL (ALL SPECIES) CPUE IN EACH REPORT PERIOD;
*COUNT THE NUMBER OF TESTFISH PERIODS IN EACH REPORT PERIOD;
proc summary data=spcpwide nway;
 class REPORT;
 var _1-_8 sumcpue;
 output out=rncpue sum=rnspcp1-rnspcp8 rnsmcp
          mean(sumcpue)=rnmncp  n=n;
 run;

*MERGE THE ORIGINAL DATA SET WITH THE SUMMARIZED DATA SET, THEN CALCULATE:
 ESTIMATED PROPORTION OF EACH SPECIES DURING EACH TESTFISH PERIOD,
 ESTIMATED PROPORTION OF EACH SPECIES DURING EACH REPORT PERIOD,
 AND A WEIGHTED SQUARED DEVIATION OF THE TESTFISH PERIOD PROPORTION FROM
 THE REPORT PERIOD PROPORTION;
data varcalc;
 merge spcpwide rncpue;
 by REPORT;
 array cpue{8} _1-_8;
 array rnspcp{8} rnspcp1-rnspcp8;
 array phatpr{8} phatpr1-phatpr8;
 array phatrp{8} phatrp1-phatrp8;
 array sqrdev{8} sqrdev1-sqrdev8;
 weight=sumcpue/rnmncp;
 do i=1 to 8;
  phatpr{i}=cpue{i}/sumcpue;
  phatrp{i}=rnspcp{i}/rnsmcp;
  sqrdev{i}=(weight**2)*(phatpr{i}-phatrp{i})**2;
  end;
 label phatpr1='CHINOOK' phatpr2='SOCKEYE' phatpr3='COHO' phatpr4='PINK'
 phatpr5='CHUM' phatpr6='WHITE' phatpr7='OTHER' phatpr8='JACK';
 format phatpr1-phatpr8 4.3 adjcatch 5.1;
 run;
```

```
*PRINT SPECIES PROPORTIONS BY TIDE;
proc sort data=varcalc out=print; by REPORT date tide; run;
title2 'ESTIMATED SPECIES PROPORTIONS AND TOTAL ADJUSTED CATCH, BY TIDE';
run;
proc print noobs label data=print;
 var REPORT date tide adjcatch
    phatpr1 phatpr8 phatpr2 phatpr5 phatpr4 phatpr3 phatpr6 phatpr7;
 run;

*SUM THE SQUARED DEVIATIONS BY REPORT PERIOD;
proc summary data=varcalc nway;
 class REPORT;
 var sqrdev1-sqrdev8 adjcatch;
 id phatrp1-phatrp8 n date;
 output out=varprop sum=smsqdv1-smsqdv8 adjcatch;
 run;

*AND CALCULATE THE VARIANCE OF THE REPORT PERIOD PROPORTION (COCHRAN 1977);
data varprop; set varprop (drop = _type_ _freq_);
 array varprp{8} varprp1-varprp8;
 array smsqdv{8} smsqdv1-smsqdv8;
 array stdprp{8} stdprp1-stdprp8;
 array cvprop{8} cvprop1-cvprop8;
 array phatrp{8} phatrp1-phatrp8;
 do i = 1 to 8;
  varprp{i}=smsqdv{i}/(n*(n-1));
  stdprp{i}=sqrt(varprp{i});
  if phatrp{i} gt 0 then cvprop{i}=stdprp{i}/phatrp{i};
  else cvprop{i}=0;
  end;
 format phatrp1-phatrp8 5.3 stdprp1-stdprp8 3.2 adjcatch 5.1;
 label phatrp1='CHINOOK' phatrp2='SOCKEYE' phatrp3='COHO' phatrp4='PINK'
 phatrp5='CHUM' phatrp6='WHITE' phatrp7='OTHER' phatrp8='JACK';
 label stdprp1='se' stdprp2='se' stdprp3='se' stdprp4='se'
 stdprp5='se' stdprp6='se' stdprp7='se' stdprp8='se';
 run;

data out; set varprop;
 format phatrp1-phatrp8 stdprp1-stdprp8 5.4;
 file 'd:\runsasw\reptprop.93';
 put REPORT date phatrp1-phatrp8 / @11 stdprp1-stdprp8;
 run;

title2 'ESTIMATED SPECIES PROPORTIONS AND STANDARD ERRORS, BY REPORT PERIOD';
proc print label data=varprop noobs;
 var REPORT date adjcatch phatrp1 stdprp1 phatrp8 stdprp8 phatrp2 stdprp2
              phatrp5 stdprp5 phatrp4 stdprp4 phatrp3 stdprp3
              phatrp6 stdprp6 phatrp7 stdprp7;
 run;

*
*NOW MERGE DATA SET CONTAINING COUNTS WITH DATA SET CONTAINING PROPORTIONS,
 AND CALCULATE SPECIES PASSAGE ESTIMATES AND THEIR ESTIMATED VARIANCE;
*;

*GENERATE DAILY CUMULATIVE PASSAGE NUMBERS;
proc sort data=varprop; by REPORT; run;
data daypasg;
 merge offcnts varprop(in=a drop=date);
 by REPORT;
```

```
 if a;
 array phatrp{8} phatrp1-phatrp8;
 array offpsg{8} offpsg1-offpsg8;
 do i=1 to 8;
   offpsg{i}=phatrp{i}*dayoffps;
   end;
 format dayoffps offpsg1-offpsg8 8.;
 run;

data dpcum; set daypasg;
 array offpsg{8} offpsg1-offpsg8;
 array cp{8} cp1-cp8;
 retain cp 0;
 do i = 1 to 8;
   cp{i}=cp{i} + offpsg{i};
   end;
 run;

*CALCULATE VARIANCE BY REPORT PERIOD;
data pasgvar;
 merge reptcnts varprop(in=a);
 by REPORT;
 if a;
 array phatrp{8} phatrp1-phatrp8;
 array varprp{8} varprp1-varprp8;
 array rptpsg{8} rptpsg1-rptpsg8;
 array varrpt{8} varrpt1-varrpt8;
 array stdrpt{8} stdrpt1-stdrpt8;
 varoffps=stdoffps**2;
 do i=1 to 8;
   rptpsg{i}=phatrp{i}*reptpasg;
   varrpt{i}=(reptpasg**2)*varprp{i} + (phatrp{i}**2)*varoffps -
          varoffps*varprp{i};
   stdrpt{i}=sqrt(varrpt{i});
   end;
 format reptpasg rptpsg1-rptpsg8 8. varoffps varprp1-varprp8
      varrpt1-varrpt8 e9. phatrp1-phatrp8 5.3;
 label REPORT='REPORTING PERIOD';
 label rptpsg1='CHINOOK' rptpsg2='SOCKEYE' rptpsg3='COHO' rptpsg4='PINK' rptpsg5='CHUM'
    rptpsg6='WHITE' rptpsg7='OTHER' rptpsg8='JACK';
 run;

proc summary data=pasgvar;
 var rptpsg1-rptpsg8 varrpt1-varrpt8 date;
 output out=cumstat sum(rptpsg1-rptpsg8)=psg1-psg8
               sum(varrpt1-varrpt8)=varpsg1-varpsg8
               max(date)=;
 run;

data cumstat; set cumstat (drop=_type_);
 rename _freq_=nreports;
 array psg{8} psg1-psg8;
 array varpsg{8} varpsg1-varpsg8;
 array stdpsg{8} stdpsg1-stdpsg8;
 array cv{8} cv1-cv8;
 do i = 1 to 8;
   stdpsg{i}=sqrt(varpsg{i});
   if psg{i}=0 then cv{i}=0;
   else cv{i}=100*stdpsg{i}/psg{i};
   end;
```

```
run;

data std; set cumstat (keep=stdpsg1-stdpsg8);
  rename stdpsg1=cp1; rename stdpsg2=cp2; rename stdpsg3=cp3; rename stdpsg4=cp4;
  rename stdpsg5=cp5; rename stdpsg6=cp6; rename stdpsg7=cp7; rename stdpsg8=cp8;
  type = 'STD ERROR';
  run;

data cv; set cumstat (keep=cv1-cv8);
  rename cv1=cp1; rename cv2=cp2; rename cv3=cp3; rename cv4=cp4;
  rename cv5=cp5; rename cv6=cp6; rename cv7=cp7; rename cv8=cp8;
  type = 'C.V. (%)';
  run;

data missing;
  cv1=.; cv2=.; cv3=.; cv4=.; cv5=.; cv6=.; cv7=.; cv8=.;
  run;

data print; set dpcum missing std cv;
  format cp1-cp8 7.;
  label cp1='CHINOOK' cp2='SOCKEYE' cp3='COHO'  cp4='PINK'
      cp5='CHUM'   cp6='WHITE'   cp7='OTHER' cp8='JACK';
  label type='.';
  run;

title2 'CUMULATIVE PASSAGE BY DAY, DERIVED FROM 3+ DAY REPORTING PERIOD PROPORTIONS';
proc print data=print label noobs;
  var type REPORT date cp1 cp8 cp2 cp5 cp4 cp3 cp6 cp7;
  run;
```

Appendix A.2. Input data file SPCMSH93.BTF called by BTF93.SAS to set mesh sizes to be used for each species in adjusting catch by net selectivity coefficients.

SPCMSH93.BTF: sets which meshes will be used (by BTF93.SAS) to estimate CPUE for each species and also sets which species' catches will be adjusted for net selectivity.

A "1" in the column for a given mesh indicates that fish of that species caught in that mesh will be used to calculate relative CPUE and in turn allocate sonar counts to species.

A "Y" in the ADJUST column will cause the program to adjust catches of that species for net selectivity, a "N" will cause the program to not adjust.

SPECIES	2.5	4.0	5.375	6.5	8.0	ADJUST?
CHINOOK	0	0	1	1	1	Y
SOCKEYE	0	0	1	1	0	Y
COHO	0	0	1	1	0	Y
PINK	0	1	0	0	0	N
CHUM	0	0	1	1	0	Y
WHITE	1	1	1	0	0	Y
OTHER	0	1	1	1	0	N
JACK	0	0	1	1	0	Y
NONE	0	0	0	0	0	N

Appendix A.3. Input data file NETSEL93.BTF called by BTF93.SAS to set net selectivity coefficients for species-mesh combinations.

NETSEL93.BTF: **source of net selectivity estimates for BTF93.SAS**
Values are read from **specific** columns:

SPECIES	LENGTH	2.5"	4.0"	5.4"	6.5"	8.0"
COHO	400		0.999			
COHO	440		0.884			
COHO	480		0.804	0.796		
COHO	520		0.469	0.977		
COHO	560		0.297	0.981	0.549	
COHO	600		0.195	0.681	0.892	
COHO	640			0.283	0.993	
CHUM	440		0.647	0.277		
CHUM	480		0.695	0.790		
CHUM	520		0.161	1.000	0.163	
CHUM	560			0.773	0.804	
CHUM	600			0.390	0.950	
CHUM	640			0.319	0.990	0.286
CHUM	680			0.245	0.847	0.472
JACK	450		0.676	0.759		
JACK	550		0.237	0.987	0.812	
JACK	650		0.316	0.384	0.999	0.339
CHINOOK	650		0.316	0.384	0.999	0.339
CHINOOK	750		0.143	0.317	0.799	0.963
CHINOOK	850		0.292	0.324	0.846	0.985
CHINOOK	950		0.281	0.659	0.642	0.902
CHINOOK	1050			0.325	0.355	0.781
SOCKEYE	440		0.784	0.291		
SOCKEYE	480		0.787	0.394		
SOCKEYE	520		0.349	0.988		
SOCKEYE	560		0.294	0.945	0.200	
SOCKEYE	600		0.342	0.646	0.895	
SOCKEYE	640		0.466	0.443	0.999	0.241
SOCKEYE	680		0.936	0.936	0.780	
WHITE	320		0.281			
WHITE	360		0.721			
WHITE	400		0.994			
WHITE	440		0.869			
WHITE	480		0.691	0.414		
WHITE	520			0.948		

Appendix B.1. Cumulative estimated fish passage at the Kuskokwim River sonar site, 1993.

DATE	King			Red	Chum	Pink	Coho	White-fish	Other	Total
	Large	Small	Total							
06/01	0	0	0	0	0	0	0	0	0	0
06/02	0	0	0	0	0	0	0	0	0	0
06/03	174	477	651	105	17	0	0	0	0	773
06/04	534	1466	2000	323	51	0	0	0	0	2374
06/05	881	2416	3297	532	84	0	0	0	0	3913
06/06	1271	3488	4759	768	122	0	0	0	0	5649
06/07	1770	4855	6625	1069	169	0	0	0	0	7863
06/08	1923	5275	7198	1162	184	0	0	0	0	8544
06/09	3872	8273	12145	1623	1286	0	0	0	0	15054
06/10	4706	9557	14263	1821	1758	0	0	0	0	17842
06/11	6035	11601	17636	2136	2509	0	0	0	0	22281
06/12	6886	12425	19311	4009	3006	0	0	173	0	26499
06/13	7927	13433	21360	6300	3612	0	0	384	0	31656
06/14	8934	14409	23343	8518	4200	0	0	589	0	36650
06/15	10500	18087	28587	16616	5378	0	0	727	52	51360
06/16	11636	20757	32393	22495	6233	0	0	828	89	62038
06/17	13651	25491	39142	32919	7750	0	0	1007	156	80974
06/18	15193	28805	43998	40788	10061	0	0	1522	543	96912
06/19	16661	31961	48622	48278	12261	0	0	2012	912	112085
06/20	18170	35206	53376	55982	14523	0	0	2516	1291	127688
06/21	19160	37086	56246	63853	20679	0	0	3498	1652	145928
06/22	20148	38963	59111	71713	26827	0	0	4479	2013	164143
06/23	21184	40932	62116	79958	33276	0	0	5508	2392	183250
06/24	21805	42598	64403	93130	45985	0	0	5508	3871	212897
06/25	22358	44082	66440	104859	57302	0	0	5508	5188	239297
06/26	22780	45214	67994	113811	65939	0	0	5508	6193	259445
06/27	23742	46206	69948	127385	70470	0	0	8811	6424	283038
06/28	25024	47525	72549	145460	76502	0	0	13209	6732	314452
06/29	26133	48667	74800	161103	81723	0	0	17014	6998	341638
06/30	26657	48843	75500	187448	97317	0	0	17221	7197	384683
07/01	27144	49007	76151	211926	111805	0	0	17413	7382	424677
07/02	27489	49123	76612	229274	122073	0	0	17550	7513	453022
07/03	27620	49314	76934	233507	133119	0	0	26702	7877	478139
07/04	27771	49533	77304	238358	145778	0	0	37189	8294	506923
07/05	27933	49768	77701	243549	159326	0	0	48413	8741	537730
07/06	28090	50120	78210	251473	169354	0	0	63053	8741	570831
07/07	28225	50422	78647	258284	177974	0	0	75638	8741	599284
07/08	28368	50740	79108	265449	187043	0	0	88877	8741	629218
07/09	28917	51319	80236	267869	193734	0	0	111736	8741	662316
07/10	29468	51900	81368	270296	200448	0	0	134669	8741	695522
07/11	30030	52493	82523	272772	207294	0	0	158053	8741	729383
07/12	30086	52584	82670	274630	222342	0	276	179914	9042	768874
07/13	30140	52674	82814	276451	237079	0	547	201322	9337	807550
07/14	30201	52774	82975	278485	253547	0	849	225245	9667	850768
07/15	30201	53025	83226	279653	277211	487	951	244680	10078	896286
07/16	30201	53265	83466	280763	299702	949	1048	263153	10468	939549
07/17	30201	53423	83624	281500	314627	1256	1112	275411	10727	968257
07/18	30201	53551	83752	281500	334680	1256	3253	281252	10727	996420
07/19	30201	53682	83883	281500	355455	1256	5471	287305	10727	1025597
07/20	30201	53796	83997	281500	373412	1256	7388	292536	10727	1050816
07/21	30201	53880	84081	281684	384007	1256	9938	308057	10727	1079750
07/22	30201	53951	84152	281838	392887	1256	12075	321066	10727	1104001
07/23	30201	54034	84235	282021	403417	1256	14609	336491	10727	1132756
07/24	32502	54570	87072	282021	407322	1256	25905	346350	11309	1161235
07/25	34700	55082	89782	282021	411051	1256	36693	355765	11865	1188433
07/26	36598	55524	92122	282021	414272	1256	46010	363896	12344	1211921
07/27	36784	55524	92308	282186	416046	1256	60998	367262	12504	1232560
07/28	36934	55524	92458	282319	417468	1256	73017	369961	12632	1249111
07/29	37094	55524	92618	282461	418995	1256	85923	372860	12770	1266883
07/30	37094	55524	92618	282461	419771	1679	98813	373146	12770	1281258
07/31	37094	55524	92618	282461	420445	2046	110003	373394	12770	1293737

-Continued-

Appendix B.1. Continued (page 2 of 2).

DATE	King			Red	Chum	Pink	Coho	White-fish	Other	Total
	Large	Small	Total							
08/01	37094	55524	92618	282461	421143	2426	121599	373652	12770	1306669
08/02	37094	55524	92618	282461	421347	2426	132901	373652	12770	1318175
08/03	37094	55524	92618	282461	421608	2426	147304	373652	12770	1332839
08/04	37094	55524	92618	282461	421858	2426	161129	373652	12770	1346914
08/05	37094	55524	92618	282461	422053	2426	172133	373970	12807	1358468
08/06	37094	55524	92618	282461	422277	2426	184821	374338	12849	1371790
08/07	37094	55524	92618	282461	422453	2426	194752	374625	12882	1382217
08/08	37094	55524	92618	282461	422453	2426	206639	374625	12882	1394104
08/09	37094	55524	92618	282461	422453	2426	216881	374625	12882	1404346
08/10	37094	55524	92618	282461	422453	2426	227607	374625	12882	1415072
08/11	37094	55524	92618	282461	422597	2426	237897	376345	12882	1427226
08/12	37094	55524	92618	282461	422751	2426	248923	378188	12882	1440249
08/13	37094	55524	92618	282461	422862	2426	256845	379512	12882	1449606
08/14	37094	55524	92618	282461	422862	2426	265261	380594	12882	1459104
08/15	37094	55524	92618	282461	422862	2426	273315	381629	12882	1468193
08/16	37094	55524	92618	282461	422862	2426	287994	383516	12882	1484759
08/17	37094	55524	92618	282461	422862	2426	296431	383685	12882	1493365
08/18	37094	55524	92618	282461	422862	2426	303549	383828	12882	1500626
08/19	37094	55524	92618	282461	422862	2426	310823	383973	12882	1508045
08/20	37094	55524	92618	282461	422862	2426	317025	384098	12882	1514372

Appendix B.2. Daily estimated fish passage at the Kuskokwim River sonar site, 199

DATE	King			Red	Chum	Pink	Coho	White-fish	Other	Total
	Large	Small	Total							
06/01	0	0	0	0	0	0	0	0	0	0
06/02	0	0	0	0	0	0	0	0	0	0
06/03	174	477	651	105	17	0	0	0	0	773
06/04	360	989	1349	218	34	0	0	0	0	1601
06/05	347	950	1297	209	33	0	0	0	0	1539
06/06	390	1072	1462	236	38	0	0	0	0	1736
06/07	499	1367	1866	301	47	0	0	0	0	2214
06/08	153	420	573	93	15	0	0	0	0	681
06/09	1949	2998	4947	461	1102	0	0	0	0	6510
06/10	834	1284	2118	198	472	0	0	0	0	2788
06/11	1329	2044	3373	315	751	0	0	0	0	4439
06/12	851	824	1675	1873	497	0	0	173	0	4218
06/13	1041	1008	2049	2291	606	0	0	211	0	5157
06/14	1007	976	1983	2218	588	0	0	205	0	4994
06/15	1566	3678	5244	8098	1178	0	0	138	52	14710
06/16	1136	2670	3806	5879	855	0	0	101	37	10678
06/17	2015	4734	6749	10424	1517	0	0	179	67	18936
06/18	1542	3314	4856	7869	2311	0	0	515	387	15938
06/19	1468	3156	4624	7490	2200	0	0	490	369	15173
06/20	1509	3245	4754	7704	2262	0	0	504	379	15603
06/21	990	1880	2870	7871	6156	0	0	982	361	18240
06/22	988	1877	2865	7860	6148	0	0	981	361	18215
06/23	1036	1969	3005	8245	6449	0	0	1029	379	19107
06/24	621	1666	2287	13172	12709	0	0	0	1479	29647
06/25	553	1484	2037	11729	11317	0	0	0	1317	26400
06/26	422	1132	1554	8952	8637	0	0	0	1005	20148
06/27	962	992	1954	13574	4531	0	0	3303	231	23593
06/28	1282	1319	2601	18075	6032	0	0	4398	308	31414
06/29	1109	1142	2251	15643	5221	0	0	3805	266	27186
06/30	524	176	700	26345	15594	0	0	207	199	43045
07/01	487	164	651	24478	14488	0	0	192	185	39994
07/02	345	116	461	17348	10268	0	0	137	131	28345
07/03	131	191	322	4233	11046	0	0	9152	364	25117
07/04	151	219	370	4851	12659	0	0	10487	417	28784
07/05	162	235	397	5191	13548	0	0	11224	447	30807
07/06	157	352	509	7924	10028	0	0	14640	0	33101
07/07	135	302	437	6811	8620	0	0	12585	0	28453
07/08	143	318	461	7165	9069	0	0	13239	0	29934
07/09	549	579	1128	2420	6691	0	0	22859	0	33098
07/10	551	581	1132	2427	6714	0	0	22933	0	33206
07/11	562	593	1155	2476	6846	0	0	23384	0	33861
07/12	56	91	147	1858	15048	0	276	21861	301	39491
07/13	54	90	144	1821	14737	0	271	21408	295	38676
07/14	61	100	161	2034	16468	0	302	23923	330	43218
07/15	0	251	251	1168	23664	487	102	19435	411	45518
07/16	0	240	240	1110	22491	462	97	18473	390	43263
07/17	0	158	158	737	14925	307	64	12258	259	28708
07/18	0	128	128	0	20053	0	2141	5841	0	28163
07/19	0	131	131	0	20775	0	2218	6053	0	29177
07/20	0	114	114	0	17957	0	1917	5231	0	25219
07/21	0	84	84	184	10595	0	2550	15521	0	28934
07/22	0	71	71	154	8880	0	2137	13009	0	24251
07/23	0	83	83	183	10530	0	2534	15425	0	28755
07/24	2301	536	2837	0	3905	0	11296	9859	582	28479
07/25	2198	512	2710	0	3729	0	10788	9415	556	27198
07/26	1898	442	2340	0	3221	0	9317	8131	479	23488
07/27	186	0	186	165	1774	0	14988	3366	160	20639
07/28	150	0	150	133	1422	0	12019	2699	128	16551
07/29	160	0	160	142	1527	0	12906	2899	138	17772
07/30	0	0	0	0	776	423	12890	286	0	14375
07/31	0	0	0	0	674	367	11190	248	0	12479

-Continued-

Appendix B.2. Continued (page 2 of 2).

DATE	King			Red	Chum	Pink	Coho	White-fish	Other	Total
	Large	Small	Total							
08/01	0	0	0	0	698	380	11596	258	0	12932
08/02	0	0	0	0	204	0	11302	0	0	11506
08/03	0	0	0	0	261	0	14403	0	0	14664
08/04	0	0	0	0	250	0	13825	0	0	14075
08/05	0	0	0	0	195	0	11004	318	37	11554
08/06	0	0	0	0	224	0	12688	368	42	13322
08/07	0	0	0	0	176	0	9931	287	33	10427
08/08	0	0	0	0	0	0	11887	0	0	11887
08/09	0	0	0	0	0	0	10242	0	0	10242
08/10	0	0	0	0	0	0	10726	0	0	10726
08/11	0	0	0	0	144	0	10290	1720	0	12154
08/12	0	0	0	0	154	0	11026	1843	0	13023
08/13	0	0	0	0	111	0	7922	1324	0	9357
08/14	0	0	0	0	0	0	8416	1082	0	9498
08/15	0	0	0	0	0	0	8054	1035	0	9089
08/16	0	0	0	0	0	0	14679	1887	0	16566
08/17	0	0	0	0	0	0	8437	169	0	8606
08/18	0	0	0	0	0	0	7118	143	0	7261
08/19	0	0	0	0	0	0	7274	145	0	7419
08/20	0	0	0	0	0	0	6202	125	0	6327

Appendix C.1. Set gillnet CPUE at the Kuskokwim River sonar site, 1993.

Date	Chinook	Jack	CPUE Sockeye	Chum	Pink	Coho	Whitefish	Cisco	Other
06JUN93	0	0	0	0	0	0	0	0	0
07JUN93	0	0	0	0	0	0	0	0	0
08JUN93	0	0.009	0	0	0	0	0	0	0
09JUN93	0	0	0	0	0	0	0	0	0
10JUN93	0	0	0	0	0	0	0	0	0
11JUN93	0	0	0	0	0	0	0	0	0
12JUN93	0	0	0	0	0	0	0	0	0
13JUN93	0	0	0	0	0	0	0	0	0
14JUN93	0	0	0	0	0	0	0	0.0235	0
15JUN93	0	0	0	0	0	0	0	0	0
16JUN93	0	0	0	0	0	0	0	0	0
17JUN93	0	0.0291	0	0	0	0	0	0	0
18JUN93	0	0.0101	0.0302	0	0	0	0.0101	0.0101	0
19JUN93	0.0202	0.0202	0.0303	0.0202	0	0	0.0101	0	0.0202
20JUN93	0.0153	0.0763	0.0916	0.0153	0	0	0	0	0
21JUN93	0.0158	0.0158	0.087	0.0079	0	0	0	0	0.0237
22JUN93	0.0147	0.0366	0.1026	0.0293	0	0	0	0	0
23JUN93	0	0	0.0515	0	0	0	0.0147	0	0
24JUN93	0	0	0.0348	0.0557	0	0	0.007	0.007	0
25JUN93	0	0.008	0.0402	0	0	0	0.0161	0	0.008
26JUN93	0	0	0	0	0	0	0.0204	0	0
27JUN93	0	0	0.0635	0	0	0	0.0317	0	0
28JUN93	0	0.0083	0.0167	0.0167	0	0	0.0083	0	0
29JUN93	0	0.0101	0.0704	0.0101	0	0	0.0503	0	0
30JUN93	0.0385	0.044	0.1154	0.011	0	0	0	0	0
02JUL93	0	0	0.0559	0.0559	0	0	0.0335	0.0112	0
03JUL93	0.0179	0	0.0893	0.1607	0	0	0.125	0	0
04JUL93	0	0	0.0238	0.0952	0	0	0	0.0238	0
06JUL93	0	0	0	0.0135	0	0	0.027	0	0
07JUL93	0	0	0.0235	0.0353	0	0	0.0118	0	0.0118
08JUL93	0	0	0.0163	0.0163	0	0	0.0244	0	0.0081
09JUL93	0	0	0	0.0412	0	0	0	0.0619	0.0103
10JUL93	0	0	0	0.027	0	0	0	0.0541	0.027
11JUL93	0	0	0.0417	0.0625	0.0208	0	0	0.1458	0
12JUL93	0	0	0	0.0415	0	0	0.0415	0.0725	0.0104
13JUL93	0	0	0.0054	0.1253	0.0054	0	0.2016	0	0
14JUL93	0	0	0.01	0.11	0.005	0	0.03	0.015	0
15JUL93	0	0	0	0.1412	0.0078	0	0.0471	0	0
16JUL93	0	0	0	0	0	0.0167	0	0.0167	0
17JUL93	0	0	0	0.025	0	0	0.025	0	0
18JUL93	0	0.0107	0.0321	0.107	0.0107	0.0107	0.0107	0.0428	0
19JUL93	0	0	0.0282	0.2254	0.0141	0	0.0423	0.0141	0.0141
20JUL93	0	0	0	0.0351	0	0.0351	0	0.1228	0.0088
21JUL93	0	0	0.0019	0.0094	0.0019	0	0	0.0019	0
22JUL93	0	0	0	0.5379	0	0.1103	0	0.0138	0.0138
24JUL93	0	0	0	0.0294	0	0	0	0.1176	0
25JUL93	0	0	0	0.011	0.011	0	0.0331	0	0.011
27JUL93	0	0	0	0	0	0.0235	0	0.1529	0
28JUL93	0	0	0	0	0	0.04	0	0.016	0
29JUL93	0	0	0	0.0105	0.0105	0.0628	0.0209	0.0524	0
30JUL93	0.0086	0	0	0	0.0172	0.1459	0	0.0086	0
31JUL93	0	0	0	0	0	0	0	0.0267	0
01AUG93	0	0	0	0	0	0.0183	0	0.1468	0.0183
04AUG93	0	0	0	0	0	0.0233	0	0	0
05AUG93	0	0	0	0	0	0.0553	0.0092	0.0369	0
06AUG93	0	0	0	0.0142	0	0.0426	0	0	0
07AUG93	0	0	0	0	0	0	0.0101	0.0606	0
08AUG93	0	0	0	0	0	0	0.0173	0	0
09AUG93	0	0	0	0	0	0	0	0.2975	0
10AUG93	0	0	0.0104	0	0	0.0104	0.0417	0.0208	0.0104
11AUG93	0	0	0	0	0	0.0101	0	0.0101	0
12AUG93	0	0	0	0	0	0.0571	0.0095	0	0
13AUG93	0	0	0	0	0	0.1835	0	0.2385	0
14AUG93	0	0	0	0	0	0.0265	0.0132	0	0
15AUG93	0	0	0	0	0	0.0556	0	0	0
16AUG93	0	0	0	0	0	0.0317	0	0	0
17AUG93	0	0	0	0	0	0.0606	0	0.0808	0.0202
18AUG93	0	0	0	0	0	0.02	0	0	0.01